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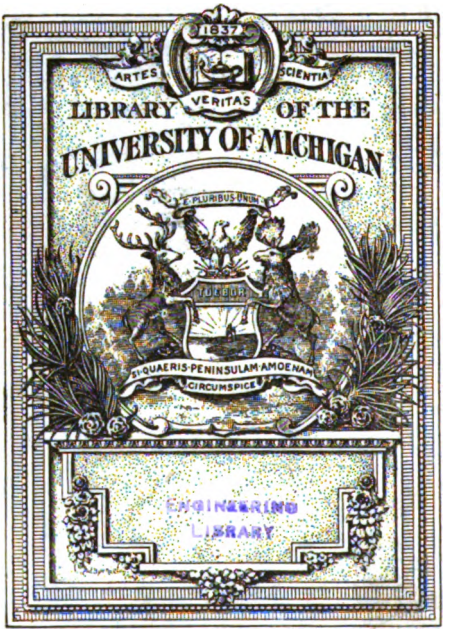

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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

FOR THE

FISCAL YEAR ENDED JUNE 30, 1899.

REPORT OF THE

CHIEF OF ENGINEERS.

PART 5.

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ARRANGEMENT OF THE ANNUAL REPORTS OF THE WAR DEPARTMENT FOR THE YEAR ENDING JUNE 30, 1899.

VOLUME I. **Parts 1–6.—Report of the Secretary of War and all other reports except those of the Chief of Engineers and the Chief of Ordnance.**

VOLUME II. **Parts 1–6.—Report of the Chief of Engineers.**

VOLUME III. **Report of the Chief of Ordnance.**

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MISCELLANEOUS.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

Under authority of special acts of Congress.—(1) Bridge of the Mineral Range Railroad Company across Portage Lake between Houghton and Hancock, Mich., (2) bridge of Monroe County, Miss., across Tombigbee River, (3) bridge of the Pocahontas Bridge Company across Black River at Pocahontas, Ark., (4) bridge of the Choctaw and Memphis Railroad Company across Arkansas River at Little Rock, Ark., 618; (5) bridge of the Choctaw and Memphis Railroad Company across Fourche Le Fevre River, Ark., (6) bridge of the Georgia and Alabama Railway Company across Savannah River, Ga., between Hutchinsons Island and the mainland, (7) bridge of the Dubuque and Dunleith Bridge Company across Mississippi River between Dubuque, Iowa. and Dunleith (East Dubuque), Ill., (8) bridges of the Rutland Canadian Railroad Company in and across Lake Champlain between Colchester and South Hero, Grand Isle and North Hero, North Hero and Alburg, Vt., (9) bridge of the Grand Trunk Railway Company and the International Bridge Company (international bridge) across Niagara River at Buffalo, N. Y., (10) bridge of the Shreveport and Red River Valley Railway Company across Loggy Bayou, La., (11) bridge of the Kansas City and Atlantic Railway Company across Missouri River at Kansas City, Mo., (12) bridge of the New York and New Jersey Bridge Company across Hudson River, (13) bridge of the Niagara River Bridge and Tunnel Company across Niagara River at Grand Island, near Buffalo, N. Y., 619; (14) bridge of the Coraopolis and Sewickley Bridge Company across Ohio River at Sewickley, Pa., (15) bridge of the city of Marietta across Muskingum River at Marietta, Ohio, (16) bridge of the Texarkana and Fort Smith Railroad Company across Red River, near Texarkana, Ark., 620.

Under authority of State laws.—(1) Bridge of the San Francisco and San Joaquin Valley Railway Company across San Joaquin River, near Stockton, Cal., (2) bridge of the Chicago and Northwestern Railway Company across Fox River at Oshkosh, Wis., (3) bridge of Dyer County, Tenn., across South Fork of Forked Deer River, at Yellow Bluff, (4) bridge of the city of Cambridge, Mass., across Charles River between Boston and Cambridge, Mass., (5) bridge of the Chicago, Milwaukee and St. Paul Railway Company across North Branch of Chicago River near Clybourn Place, Chicago, Ill., (6) bridge of the Wappoo Bridge Company across Wappoo Cut, between St. Andrews Parish and James Island, S. C., 620; (7) bridge of the Portland and Cape Elizabeth Railway Company across Portland Harbor, Me., (8) bridge of Lorain County, Ohio, across Black River at Lorain, Ohio, (9) bridge of the San Francisco and San Joaquin Valley Railway Company across Middle River, Cal., (10) bridge of the San Francisco and San Joaquin Valley Railway Company across Old River, Cal., (11) bridge of the Walkerton and Mattaponi Bridge Company across Mattaponi River at Walkerton, Va., (12) bridge of the city of Milwaukee, Wis., across Milwaukee River at Huron street, (13) bridge of Clay County, W. Va., across Elk River at Clay, (14) bridge of the Brooklyn and Jamaica Bay Turnpike Company across Beach Channel, Jamaica Bay, at Rockaway Beach, N. Y., (15) bridge of the city of Milwaukee, Wis., across Kinnickinnic River at Lincoln avenue, (16) bridge of the Chicago and Northwestern Railway Company across Embarrass River at New London, Wis., (17) bridge of the Chicago, Milwaukee and St. Paul Railway Company across Fox River at Omro, Wis., (18) bridge of the city of Oshkosh, Wis., across Sawyer Creek, (19) bridge of the Norfolk and Atlantic Terminal Company across Tanners Creek near Norfolk, Va., (20) bridges of the town of Phippsburg, Me., across Morse and Sprague rivers, 621; (21) bridge of the Cleveland, Cincinnati, Chicago and St. Louis Railway Company across Cuyahoga River at Cleveland, Ohio, (22) bridge of the Maine Central Railroad Company across Mill Creek at Thomaston, Me., (23) bridge of the Chicago Terminal Transfer Railway across South Branch of Chicago River south of Taylor street, Chicago, Ill., (24) bridge of the Pittsburg, Cincinnati, Chicago and St. Louis Railway Company across Little Calumet River at Riverdale, Ill., (25) bridge of the Chicago and Northwestern Railway Company across Manitowoc River at Manitowoc, Wis., (26) bridge of the city of Chicago across South Branch of Chicago River at Taylor street, (27) bridge of the Southern Branch Drawbridge Company across South Branch of Elizabeth River, Va., (28) bridge of the Lynn and Boston Railroad Company across Saugus River between Saugus and Lynn, Mass., (29) bridge of the Metropolitan Park Commission of Massachusetts across Saugus River, Mass., (30) bridge of the city of Algoma, Wis., across Ahnapee River, (31) bridge of Lake County, across Grand River, Ohio, (32) bridge of the R. Martin Sugar Company, Limited,

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IMROVEMENTS.—Port Chester Harbor, N. Y., 1208; Mamaroneck Harbor, N. Y., 1210; Larchmont Harbor, N. Y., 1213; East Chester Creek, N. Y., 1215; Bronx River, N. Y., 1217; Mattituck Harbor, N. Y., 1219; Port Jefferson Harbor, N. Y., 1220; Huntington Harbor, N. Y., 1223; Glencove Harbor, N. Y., 1225; Flushing Bay, N. Y., 1227; East River and Hell Gate, N. Y., 1229; Harlem River, N. Y., 1232; Newtown Creek, N. Y., 1239; Wallabout Channel, N. Y., 1242; Canarsie Bay, N. Y., 1245; Browns Creek, Sayville, Long Island, N. Y., 1247; Patchogue River, N. Y., 1249; removing sunken vessels or craft obstructing or endangering navigation, 1251.

SURVEY.—Wallabout Channel, N. Y., 1251.

HARBOR LINES.—East River at Rikers Island, N. Y., 1254; East River at Oak Point, New York, N. Y., 1255; East River, between East Twenty-third and East Twenty-fourth streets, New York, N. Y., 1258.

APPENDIX F.

REPORT OF MAJ. H. M. ADAMS, CORPS OF ENGINEERS.

IMPROVEMENTS.—New York Harbor, N. Y., 1261; Bay Ridge Channel, the triangular area between Bay Ridge and Red Hook channels, and Red Hook and Buttermilk channels, New York Harbor, 1266; Gowanus Creek Channel, N. Y., 1274; removing sunken vessels or craft obstructing or endangering navigation, 1276.

SURVEY.—East Channel, New York Harbor, from the Narrows to the sea, 1279.

APPENDIX G.

REPORT OF COL. J. W. BARLOW, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Burlington, Vt., 1289; Otter Creek, Vt., 1291; Narrows of Lake Champlain, N. Y. and Vt., 1292; Hudson River, N. Y., 1293; harbor at Saugerties, N. Y., 1299; harbor at Rondout, N. Y., 1300; harbor at Peekskill, N. Y., 1301; Passaic River, N. J., 1303; channel between Staten Island and New Jersey, 1304; Elizabeth River, N. J., 1305; Raritan River, N. J. 1306; South River, N. J., 1307; Raritan Bay, N. J., 1308; Matawan Creek, N. J., 1309; harbor at Keyport, N. J., 1310; Shoal Harbor and Compton Creek, N. J., 1312; Shrewsbury River, N. J., 1313; Manasquan River, N. J., 1314; removing sunken vessels or craft obstructing or endangering navigation, 1315.

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APPENDIX H.

REPORT OF LIEUT. COL. C. W. RAYMOND. CORPS OF ENGINEERS.

IMPROVEMENTS.—Delaware River, N. J. and Pa., 1317; harbor between Philadelphia, Pa., and Camden, N. J., 1328; Schuylkill River, Pa., 1339; ice harbor at Marcushook, Pa., iron pier in Delaware Bay, near Lewes, Del., 1344; Delaware Breakwater, Del., 1345; harbor of refuge, Delaware Bay, Del., 1354; Rancocas River, N. J., 1356; Alloway Creek. N. J., 1358; Cooper Creek, N. J., 1360; Goshen Creek, N. J., 1362; Mantua Creek, N. J., 1364; removing sunken vessels or craft obstructing or endangering navigation, 1367.

APPENDIX I.

REPORT OF WM. F. SMITH, UNITED STATES AGENT, MAJOR OF ENGINEERS, UNITED STATES ARMY, RETIRED.

IMPROVEMENTS.—Wilmington Harbor, Del., 1369; Appoquinimink River, Del., 1374; Smyrna River, Del.. 1376; Murderkill River, Del., 1378; Mispillion River, Del., 1379; Broadkiln River, Del., 1380; inland waterway from Chincoteague Bay, Va., to Delaware Bay, at or near Lewes, Del., 1381; Susquehanna River, above and below Havre de Grace, Md., 1382; Chester River, Md., from Crumpton to Jones Landing, 1383; Choptank River, Md., 1384; La Trappe River, Md., 1386; Warwick River, Md., 1387; Broad Creek River, Del., 1389; Nanticoke River, Del. and Md., 1391; Wicomico River, Md., 1392; Manokin River, Md., 1394; Pocomoke River, Md., below Snow Hill, 1395; Queenstown Harbor, Md., Rockhall Harbor and inner harbor, at Rockhall, Md., 1397; removing sunken vessels or craft obstructing or endangering navigation, 1398.
HARBOR LINES.—Annemessex River, at Crisfield, Md., 1399.

APPENDIX J.

REPORT OF COL. PETER C. HAINS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Patapsco River and channel to Baltimore, Md., 1405; channel to Curtis Bay, in Patapsco River, Baltimore Harbor, Md., 1409; harbor of southwest Baltimore (Spring Garden), Md., removing sunken vessels or craft obstructing or endangering navigation, 1410.
HARBOR LINES.—Patapsco River, at Sparrows Point, Md., 1410.

APPENDIX K.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Potomac River at Washington, D. C., 1413; Potomac River below Washington, D. C., 1419; Occoquan Creek, Va., 1421; Aquia Creek, Va., Nomini Creek, Va., 1423; Lower Machodoc Creek, Va., 1424; Rappahannock River. Va., 1425; Urbana Creek, Va., 1428; harbor at Milford Haven, Va., 1429; York River, Va., 1431; Mattaponi River, Va., 1433; Pamunkey River, Va., 1435; James River, Va., 1436; protection of Jamestown Island, Va., 1440; removing sunken vessels or craft obstructing or endangering navigation, 1442.
SURVEY.—Anacostia River, D. C., 1443.
HARBOR LINES.—Potomac River at Washington, D. C., 1463.

APPENDIX L.

REPORT OF MAJ. THOS. L. CASEY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Norfolk and its approaches, Va., 1471; Elizabeth River, Va., 1473; Western Branch of Elizabeth River, Va., 1474; Nansemond River, Va., 1475; Appomattox River, Va., 1476; harbor at Cape Charles City, Va., 1478; Nandua Creek, Va., 1479; inland water route from Norfolk, Va., to the sounds of North Carolina, 1480; inland water route from Norfolk, Va., to Albemarle Sound, N. C., through Currituck Sound, 1481; Edenton Bay, N. C., 1482; Roanoke River, N. C., 1483; Pasquotank River, N. C., removing sunken vessels or craft obstructing or endangering navigation, 1484.
SURVEY.—Deep Creek Branch, Elizabeth River, Va., 1485.

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APPENDIX M.

REPORT OF CAPT. E. W. VAN C. LUCAS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ocracoke Inlet, N. C., 1487; Fishing Creek, N. C., 1489; Pamlico and Tar rivers, N. C., 1490; Contentnia Creek, N. C., 1492; Trent River, N. C., 1493; Neuse River, N. C., 1495; inland waterway between Newbern and Beaufort, N. C., via Clubfoot, Harlowe, and Newport rivers, 1497; harbor at Beaufort, N. C., 1498; inland waterway between Beaufort Harbor and New River, N. C., 1499; New River, N. C., 1501; Black River, N. C., 1502; Northeast (Cape Fear) River, N. C., 1504; Cape Fear River above Wilmington, N. C., 1505; Cape Fear River at and below Wilmington, N. C., 1507; Town Creek, Brunswick County, N. C., 1515; removing sunken vessels or craft obstructing or endangering navigation, 1516.

APPENDIX N.

REPORT OF MAJ. E. H. RUFFNER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Waccamaw River, N. C. and S. C., 1517; Little Pedee River, S. C., 1521; Great Pedee River, S. C., 1523; Georgetown Harbor, S. C., 1526; Winyah Bay, S. C., 1527; Santee River, S. C., 1532; Wateree River, S. C., 1536; Congaree River, S. C., 1539; Congaree River, S. C., from Gervais Street Bridge, Columbia, to Granby, harbor at Charleston, including Sullivan Island and Mount Pleasant shore, S. C., 1542; Wappoo Cut, S. C., 1546; Beaufort River, S. C., 1548; removing sunken vessels or craft obstructing or endangering navigation, 1550.

SURVEY.—Entrance to Charleston Harbor, S. C., 1551.

APPENDIX O.

REPORT OF CAPT. CASSIUS E. GILLETTE, CORPS OF ENGINEERS.

IMPROVEMENTS.—Savannah Harbor, Ga., 1559; Savannah River between Augusta and Savannah, Ga., 1567; Savannah River above Augusta, Ga., 1571; Doboy Bar, Ga., 1573; Darien Harbor, Ga., 1574; Altamaha River, Ga., 1578; Oconee River, Ga., 1580; Ocmulgee River, Ga., 1582; Brunswick Harbor, Ga., 1585; inside water route between Savannah, Ga., and Fernandina, Fla., 1590; removing sunken vessels or craft obstructing or endangering navigation, 1592.

APPENDIX P.

REPORT OF CAPT. C. H. McKINSTRY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Cumberland Sound, Ga. and Fla., 1593; St. Johns River, Fla., from Jacksonville to the ocean, 1597; St. Johns River at Orange Mills Flats, Fla., 1600; Volusia Bar, Fla., 1602; Ocklawaha River, Fla., 1603; St. Augustine Harbor, Fla., 1607; Indian River, Fla., 1608; harbor at Key West, Fla., and entrance thereto, 1610; removing the water hyacinth from Florida waters, 1612; dredge for river and harbor improvements, Fla., 1613.

SURVEY.—Removing water hyacinths from navigable waters of Florida and Louisiana, 1613.

APPENDIX Q.

REPORT OF CAPT. HENRY JERVEY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Caloosahatchee River, Fla., 1625; Charlotte Harbor and Pease Creek, Fla., 1626; Sarasota Bay, Fla., 1629; Manatee River, Fla., 1630; Tampa Bay, Fla., 1632; Hillsboro Bay, Fla., 1635; Anclote River, Fla., Withlacoochee River, Fla., 1638; Suwanee River, Fla., 1639.

SURVEY.—Tampa Bay, Fla., from Port Tampa to mouth of bay, in Gulf of Mexico, 1640.

HARBOR LINES.—Hillsboro River at Tampa, Fla., 1643.

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APPENDIX R.

REPORT OF CAPT. C. A. F. FLAGLER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Carrabelle Bar and Harbor, Fla., 1647; Apalachicola Bay, Fla., 1649; Apalachicola River, the Cut-off, and lower Chipola River, Fla., 1653; upper Chipola River, Fla., from Marianna to its mouth, 1655; Flint River, Ga., 1657; Chattahoochee River, Ga. and Ala., 1660; Choctawhatchee River, Fla. and Ala., 1664; La Grange Bayou, Fla., including Holmes River, from Vernon to its mouth, 1666; Pensacola Harbor, Fla., 1668; Blackwater River, Fla., 1673; Escambia and Conecuh rivers, Fla. and Ala., 1674; Alabama River, Ala., 1676; Coosa River, Ga. and Ala., 1682; operating and care of canals and other works of navigation on Coosa River, Ga. and Ala., 1692.

APPENDIX S.

REPORT OF MAJ. WM. T. ROSSELL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Mobile, Ala., 1696; Black Warrior River, Ala., from Tuscaloosa to Daniels Creek, 1702; operating and care of locks and dams on Black Warrior River, Ala., 1703; Warrior and Tombigbee rivers, Ala. and Miss., 1707; Noxubee River, Miss., 1716; Pascagoula River, Miss., 1717; Pascagoula River and Horn Island Harbor, Miss., 1718; Chickasahay River, Miss., 1720; Leaf River, Miss., 1721; channel from Gulfport to Ship Island Harbor, Miss., 1722; Ship Island Pass, Miss., 1723; Pearl River at its mouth, Miss., 1724; Pearl River below Jackson, Miss., 1725; Pearl River between Carthage and Jackson, Miss., 1727; Pearl River between Edinburg and Carthage, Miss., 1728; Bogue Chitto, La., 1729; canal between Warrior River and Five-mile Creek, Ala., 1730; removing sunken vessels or craft obstructing or endangering navigation, 1783.
SURVEYS.—Horn Island Pass and Harbor, Miss., 1784; channel through Ship Island Pass, and from Ship Island Harbor to Gulfport and to Biloxi, Miss., 1787.

APPENDIX T.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS.

INSPECTION of the improvement of the South Pass of the Mississippi River, 1815.

APPENDIX U.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Chefuncte River and Bogue Falia, La., 1833; Tickfaw River and its tributaries, La., 1835; Amite River and Bayou Manchac, La., 1837; closing crevasse in Pass a Loutre, Mississippi River, 1839; improvement of the outlet of the Mississippi River at Pass a Loutre, 1841; Bayou Lafourche, La., 1842; Bayou Plaquemine, Grand River, and Pigeon bayous, La., 1844; Bayou Courtableau, La., 1847; Bayou Teche, La., 1848; channel, bay, and passes of Bayou Vermilion, La., 1850; Mermentau River and tributaries, La., 1851; mouth and passes of Calcasieu River, La., 1853; Johnsons Bayou, La., removing water hyacinths from Louisiana waters, 1855; mouths of Sabine and Neches rivers, Tex. 1856; Sabine River, Tex., 1857; harbor at Sabine Pass, Tex., 1858; Homochitto, River, Miss., 1862.
SURVEY.—Southwest Pass, Mississippi River, 1863.

APPENDIX V.

REPORT OF CAPT. C. S. RICHÉ, CORPS OF ENGINEERS.

IMPROVEMENTS.—Galveston Harbor, Tex., 1953; ship channel in Galveston Bay, Tex., 1961; channel from Galveston Harbor to Texas City, Tex., 1962; Galveston ship channel and Buffalo Bayou, Tex., 1964; operating and care of Morgan Canal, Tex., Trinity River, Tex., 1965; Buffalo Bayou, Tex., 1967; channel in West Galveston Bay, Tex., 1968; mouth of Brazos River, Tex., 1969; Brazos River between Velasco and Richmond, West Galveston Bay channel, Double Bayou, and mouths of adjacent streams, Tex., Brazos River, Tex., 1970; Aransas Pass, Tex., removing sunken vessels or craft obstructing or endangering navigation, 1972.
SURVEYS.—Aransas Pass and Harbor, Tex., 1973; mouth of Brazos River, near Velasco, Tex., 1976.

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APPENDIX W.

REPORT OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS.

IMPROVEMENTS.—Red River, La., Ark., and Ind. T., 1979; Red River above Fulton, Ark., 1991; Cypress Bayou, Tex. and La., 1992; Ouachita and Black rivers, Ark. and La., 1994; Bayou Bartholomew, La. and Ark., 2000; Bœuf River, La., 2002; Tensas River and Bayou Maçon, La., 2006; Yazoo River, Miss., 2009; mouth of Yazoo River and harbor at Vicksburg, Miss., 2015; Tallahatchie River, Miss., 2020; Big Sunflower River, Miss., 2022; water gauges on the Mississippi River and its principal tributaries, 2025.

APPENDIX X.

REPORT OF LIEUT. ROBERT McGREGOR, CORPS OF ENGINEERS.

IMPROVEMENTS.—Removing obstruction in Arkansas River, Ark. and Kans., 2031; Arkansas River, Ark., 2033; White River, Ark., 2035; Buffalo Fork of White River, Ark., 2037; Upper White River, Ark., 2038; Cache River, Ark., 2039; Black River, Ark. and Mo., 2040; Current River, Ark. and Mo., 2042; St. Francis River, Ark., 2043; St. Francis River, Mo., 2045.

PART III.

APPENDIX Y.

REPORT OF CAPT. EDW. BURR, CORPS OF ENGINEERS.

IMPROVEMENTS.—Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, 2047; Mississippi River between Ohio and Missouri Rivers, 2058; harbor at St. Louis, Mo., 2067; to prevent the Mississippi River from breaking through into Cache River at Beechridge, above Cairo, Ill., 2068.

APPENDIX Z.

REPORT OF CAPT. C. McD. TOWNSEND, CORPS OF ENGINEERS.

IMPROVEMENTS.—Operating snag boats and dredge boats on Upper Mississippi River, 2091; Mississippi River between mouth of Missouri River and St. Paul, 2102; operating and care of Des Moines Rapids Canal and Dry Dock, 2160; operation and care of Galena River improvement, Ill., 2168; harbor at La Crosse, Wis., 2171.

APPENDIX A A.

REPORT OF MAJ. FREDERIC V. ABBOT, CORPS OF ENGINEERS.

IMPROVEMENTS.—Mississippi River, between St. Paul and Minneapolis, Minn., 2173; construction of reservoirs at head waters of Mississippi River, 2182; operating and care of reservoirs at head waters of Mississippi River, 2190; Chippewa River, including yellow banks, Wis., 2195; St. Croix River, Wis. and Minn., 2197; Minnesota River, Minn., Red River of the North, Minn. and N. Dak., 2200; bar at mouth of Warroad River, Minn., 2204; gauging Mississippi River at or near St. Paul, Minn., 2205.

APPENDIX B B.

REPORT OF CAPT. J. C. SANFORD, CORPS OF ENGINEERS.

IMPROVEMENTS.—Missouri River between Stubbs Ferry, Mont., and lower limits of Sioux City, Iowa, 2217; snagging Upper Missouri River, 2229; Yellowstone River, Mont. and N. Dak., 2231.

APPENDIX C C.

REPORT OF LIEUT. COL. M. B. ADAMS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Obion River, Tenn., 2233; Forked Deer River, Tenn., 2235; Cumberland River, Tenn. and Ky., 2238.

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APPENDIX D D.

REPORT OF MAJ. DAN C. KINGMAN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Tennessee River system, 2251: Tennessee River, 2252; operating and care of Muscle Shoals Canal, Tennessee River, 2289; French Broad and Little Pigeon rivers, Tenn., 2300; Clinch River, Tenn. and Va., 2303; Elk River, Tenn. and Ala., 2306.
SURVEY.—Elk River, Tenn. and Ala., 2308.

APPENDIX E E.

REPORT OF MAJ. WM. H. BIXBY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ohio River, 2311; operating snag boat on the Ohio River, 2340; operating and care of Davis Island Dam, Ohio River, near Pittsburg, Pa., 2347; movable dams in Ohio River, 2352.
SURVEYS.—Ohio River, from Marietta, Ohio, to Pittsburg, Pa., final report, 2361; Ohio River at Cullums Ripple, below Cincinnati, Ohio, 2367.

APPENDIX F F.

REPORT OF MAJ. CHAS. F. POWELL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Monongahela River, W. Va. and Pa., 2373, 2375; operating and care of locks and dams on Monongahela River, W. Va. and Pa., 2376; harbor of Pittsburg, Pa., 2397; locks and dams at Herr Island, above head of Six-mile Island, and at Springdale, Allegheny River, Pa., 2404; open-channel improvement, Allegheny River, Pa., 2410.
SURVEY.—Allegheny River, Pa., 2411.
HARBOR LINE.—Ohio River at Allegheny City, Pa., 2449.

APPENDIX G G.

REPORT OF CAPT. H. F. HODGES, CORPS OF ENGINEERS.

IMPROVEMENTS.—Muskingum River, Ohio, 2454; operating and care of locks and dams on Muskingum River, Ohio, 2457; Little Kanawha River, W. Va., 2474; operating and care of lock and dam on Little Kanawha River, W. Va., 2476; Great Kanawha River, W. Va., 2479; operating and care of locks and dams on Great Kanawha River, W. Va., 2485; Elk River, W. Va., 2495; Gauley River, W. Va., 2496; New River, Va. and W. Va., 2498; Guyandotte River, W. Va., 2499; Big Sandy River, W. Va. and Ky., 2501; operating and care of lock and dam in Big Sandy River, W. Va. and Ky., 2505; Tug Fork of Big Sandy River, W. Va. and Ky., 2508; Levisa Fork of Big Sandy River, Ky., 2511; Kentucky River, Ky., 2513; operating and care of locks and dams in Kentucky River, Ky., 2523.

APPENDIX H H.

REPORT OF CAPT. GEO. A. ZINN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Falls of Ohio River at Louisville, Ky., 2545; operating and care of Louisville and Portland Canal, Louisville, Ky., 2565; Wabash River, Ind. and Ill., 2577; operating and care of lock and dam at Grand Rapids, Wabash River, 2578; White River, Ind., 2580; Lock No. 2, Green River, at Rumsey, Ky., 2581; Green River above mouth of Big Barren River, Ky. (Lock No. 5), 2583; operating and care of locks and dams on Green and Barren rivers, Ky., 2584; Rough River, Ky., 2599; operating and care of lock and dam in Rough River, Ky., 2602.

APPENDIX I I.

REPORT OF MAJ. CLINTON B. SEARS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Grand Marais, Minn., 2605; harbor at Agate Bay, Minn., 2608; harbor at Duluth, Minn., and Superior, Wis., 2611; harbor at Ashland, Wis., 2703; harbor at Ontonagon, Mich., 2705; waterway from Keweenaw Bay to Lake Superior, Mich., 2707; harbor at Marquette, Mich., 2715; harbor of refuge, Marquette Bay, Mich., 2718; harbor of refuge, Grand Marais, Mich., 2719; removing sunken vessels or craft obstructing or endangering navigation, 2722.
HARBOR LINE.—Portage Lake at Houghton, Mich., 2723.

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PART IV.

APPENDIX J J.

REPORT OF CAPT. J. G. WARREN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Menominee Harbor, Mich. and Wis., 2726; Menominee River, Mich. and Wis., 2728; Oconto Harbor, Wis., 2731; Pensaukee Harbor, Wis., Green Bay Harbor, Wis., 2734; Sturgeon Bay and Lake Michigan Ship Canal, Wis., 2737; operating and care of Sturgeon Bay and Lake Michigan Ship Canal, Wis., 2743; harbor of refuge, Sturgeon Bay Canal, Wis., 2749; Ahnapee Harbor, Wis., 2751; Kewaunee Harbor, Wis., 2754; Two Rivers Harbor, Wis., 2756; Manitowoc Harbor, Wis., 2759; Sheboygan Harbor, Wis., 2762; Port Washington Harbor, Wis., 2765; harbor of refuge at Milwaukee, Wis., 2767; Milwaukee Harbor, Wis., 2770; South Milwaukee Harbor, Wis., 2775; Racine Harbor, Wis., 2776; Kenosha Harbor, Wis., 2781; Waukegan Harbor, Ill., 2786; Fox River, Wis., 2789; operating and care of locks and dams on Fox River, Wis., 2794; removing sunken vessels or craft obstructing or endangering navigation, 2812.
SURVEYS.—Sheboygan Harbor, Wis., 2812; Racine Harbor, Wis., 2815; Kenosha Harbor, Wis., 2817.
HARBOR LINE.—Fox River, at Oshkosh, Wis., 2819.

APPENDIX K K.

REPORT OF MAJ. W. L. MARSHALL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Chicago Harbor, Ill., 2821; Chicago River, Ill., 2826; removal of wreck of schooner *John Raber* from North Branch, Chicago River, Ill., 2833, 2866; Calumet Harbor, Ill., 2833; Calumet River, Ill. and Ind., 2838; Illinois River, Ill., 2841; operating and care of Lagrange and Kampsville Locks, Illinois River, Ill., and approaches thereto, 2849; Illinois and Mississippi Canal, 2853; operating and care of Illinois and Mississippi Canal around rapids of Rock River at Milan, Ill., 2888.
SURVEY.—Upper Illinois and Lower Des Plaines rivers, Ill., 2890.
HARBOR LINE.—Calumet Harbor, Ill., 2891.

APPENDIX L L.

REPORT OF CAPT. CHESTER HARDING, CORPS OF ENGINEERS.

IMPROVEMENTS.—Michigan City Harbor, Ind., 2895; St. Joseph Harbor, Mich., 2901; St. Joseph River, Mich., 2905; South Haven Harbor, Mich., 2906; Saugatuck Harbor, Mich., 2910; Kalamazoo River, Mich., 2912; harbor at Holland (Black Lake), Mich., 2913; harbor at Grand Haven, Mich., 2917; Grand River, Mich., 2920; Muskegon Harbor, Mich., 2928; White Lake Harbor, Mich., 2931; Pentwater Harbor, Mich., 2933; Ludington Harbor, Mich., 2936; harbor at Manistee, Mich., 2939; harbor of refuge, Portage Lake, Manistee County, Mich., 2942; Frankfort Harbor, Mich., 2944; harbor at Charlevoix, Mich., 2946; harbor at Petoskey, Mich., 2949; removing sunken vessels or craft obstructing or endangering navigation, 2951.

APPENDIX M M.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ship channel connecting waters of the Great Lakes between Chicago, Duluth, and Buffalo, 2953; St. Marys River at the falls, Mich., 2960; St. Marys Falls Canal, Mich., 2965; Hay Lake Channel, St. Marys River, Mich., 2979; Cheboygan Harbor, Mich., 2982; Alpena Harbor (Thunder Bay River), Mich., 2983; Saginaw River, Mich., 2985; Sebewaing River, Mich., 2987; harbor of refuge, Sandbeach, Lake Huron, Mich., 2988; mouth of Black River, Mich., 2992; Black River at Port Huron, Mich., 2993; Pine River, Mich., 2995; Belle River, Mich., 2996; St. Clair Flats Canal, Mich., 2998; operating and care of St. Clair Flats Canal, Mich., 2999; Clinton River, Mich., 3001; Detroit River, Mich., 3003; Rouge River, Mich., 3013; turning basin in Rouge River, Mich., 3014; removing sunken vessels or craft obstructing or endangering navigation, 3015.

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APPENDIX N N.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

IMPROVEMENTS.—Monroe Harbor, Mich., 3017: Toledo Harbor, Ohio, 3020; Port Clinton Harbor, Ohio, 3034; Sandusky Harbor, Ohio, 3036; Huron Harbor, Ohio, 3051; Vermilion Harbor, Ohio, 3053; Black River (Lorain) Harbor, Ohio, 3055; Cleveland Harbor, Ohio, 3057; Fairport Harbor, Ohio, 3064: Ashtabula Harbor, Ohio, 3068; Conneaut Harbor, Ohio, 3071; removing sunken vessels or craft obstructing or endangering navigation, 3075.
SURVEY.—Cleveland Harbor, Ohio, 3075.
HARBOR LINES.—Toledo Harbor, Ohio, 3078; Cleveland Harbor, Ohio, 3080.

APPENDIX O O.

REPORT OF MAJ. THOMAS W. SYMONS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Erie Harbor, Pa., 3091; Dunkirk Harbor, N. Y., 3096; Buffalo Harbor, N. Y., 3101; Buffalo entrance to Erie Basin and Black Rock Harbor, N. Y., 3114; Tonawanda Harbor and Niagara River, N. Y., 3115; Niagara River from Tonawanda to Port Day, N. Y., 3121.
HARBOR LINE.—Outer harbor at Buffalo, N. Y., including West Seneca, 3128.

APPENDIX P P.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS.

IMPROVEMENTS.—Wilson Harbor, N. Y., 3129; harbor at Charlotte, N. Y., 3130; harbor at Pultneyville, N. Y., 3132; harbor at Great Sodus Bay, N. Y., 3133; harbor at Little Sodus Bay, N. Y., 3135; harbor at Oswego, N. Y., 3138; harbor at Cape Vincent, N. Y., 3145; shoals in the St. Lawrence River, between Ogdensburg and the foot of Lake Ontario, 3147; harbor at Ogdensburg, N. Y., 3149.

APPENDIX Q Q.

REPORT OF CAPT. JAMES J. MEYLER, CORPS OF ENGINEERS.

IMPROVEMENTS.—San Diego Harbor, Cal., 3153; deep-water harbor at San Pedro Bay, Cal., 3156; Wilmington Harbor, Cal., 3158; San Luis Obispo Harbor, Cal., 3159.

APPENDIX R R.

REPORT OF MAJ. W. H. HEUER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Alviso, Cal., 3161; harbor at San Francisco, Cal., 3162; Oakland Harbor, Cal., 3163; San Joaquin River, Cal., 3166; Mokelumne River, Cal., 3168; Sacramento and Feather rivers, Cal., 3169; Napa River, Cal., 3182; Petaluma Creek, Cal., 3183; Humboldt Harbor and Bay, Cal., 3185; removing sunken vessels or craft obstructing or endangering navigation, 3188.
SURVEY.—San Joaquin River and Stockton and Mormon channels, Cal., 3188.
HARBOR LINES.—Eastern shore of San Francisco Bay, between Point San Pablo and Oakland, Cal., 3194.

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REPORT OF CAPT. WILLIAM W. HARTS, CORPS OF ENGINEERS.

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

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[To be inserted at page 3291 Annual Report of Chief of Engineers, 1899.]

ERRATA

IN THE REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1899, AS PRINTED IN THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS, 1899, APPENDIX W W.

NOTE.—The following list includes only errors of quantity or sense.

Page 3319.—5th line under Levees, for 1899 read 1898.

" 3323.—5th line, for 80 miles read 78 miles.

" 3396.—Opposite □ $^{3}\frac{1}{4}^{4}$, 5th column, for 1,134.2 read 1,149.6.

" 3399.—Opposite □ $^{3}\frac{1}{8}^{8}$, 8th column, for □ $^{3}\frac{1}{2}$ read □ $^{3}\frac{1}{8}^{6}$.

" 3419.—3rd line, for P. B. H. $^{3}\frac{1}{8}^{2}$ read P. B. M. $^{3}\frac{1}{8}^{2}$.

" 3451.—2nd line, for P. B. $^{3}\frac{1}{8}^{5}$ read P. B. M. $^{3}\frac{1}{8}^{5}$.

" 3455.—Opposite T. B. M. 194, 7th column, for $\left\{\begin{matrix}-.10\\+.10\end{matrix}\right\}$ read $\left\{\begin{matrix}+.10.\\-.10.\end{matrix}\right\}$

" 3462.—Opposite T. B. M. 226, 2nd column, for T. B. M. 255 read T. B. M. 225.

" 3472.—6th line from bottom, for there will be parallax read there will be no parallax.

" 3480.—Opposite Memphis, in 7th column, for 37.59 read 37.22.

Opposite Arkansas City, in last three columns, for

Jan. 13	9.2	+12.8	read	Jan. 13 / Sept. 12	9.2 / 9.9 ?	..... / +13.5

" 3484.—Opposite high water gage 138, 5th column, for 220.7 read 216.9 ?, and in

6th column, for 218.2 read 218.8, and in

last column, for —2.5 read —1.9.

Opposite high water gage 130, 5th column, for 202.0 read 199.2, and in

last column, for —3.0 read —5.8.

" 3489.—6th line above work under construction, for bearings on collars read bearings or collars.

" 3503.—Table No. 13, opposite Pile Sinker No. 984, for 447.08 read 447.03.

" 3524.—Under subsistence, 3rd line, for $667.62 read $677.62.

" 3530.—2nd line from bottom, for 7 feet above zero read 7 feet below zero.

" 3566.—20th line from bottom of table, for J. F. Kerr read J. E. Kerr.

" 3576.—Opposite Shippey & Johnsen, 2nd column to right, for 58,103 read 58,105.

" 3578.—Lower table, opposite McIntyre & Howard, under Cost, for *c*16,447.44 read *c*16,447.74.

" 3605.—Opposite Nina, Section 7, 2nd column to right, for 16.26 read 16.25.

" 3610.—1st table, opposite Ballay to Orange Farm Section 5, 5th column to right, for blank read 170.

" 3618.—Under Barataria Levee District, opposite Surveys, for 84.56 read 84.66.

" 3619.—14th line, for $75,250.22 read $73,250.22.

" 3647.—1st line under Barataria Levee District, for line of levees read line of levels.

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APPENDIX W W.

ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1899.

ARMY BUILDING,
New York City, July 1, 1899.

SIR: The Mississippi River Commission has the honor to submit this its annual report for the fiscal year ending June 30, 1899.

APPROPRIATIONS AND ALLOTMENTS.

The sundry civil act of July 1, 1898, appropriated $1,983,333, from which the following allotments were made:

Mississippi River Commission	$40,000
Surveys, gauges, and observations	115,000
Dredges and dredging	358,400
Experimental low-water dikes	25,000
Plum Point Reach, repair and preservation of works	40,000
Plum Point Reach, care and repair of plant	15,000
Delta Point, La., repair and preservation of works	40,000
Delta Point, La., care and repair of plant	20,000
Fourth District, care and repair of plant	5,556
Lake Providence Reach, part of $10,000 allotment for revetment	4,377
Levees	1,075,000

The specific appropriations in the act were as follows:

New Madrid, Mo., extension of revetment	50,000
Caruthersville, Mo., bank protection	20,000
Memphis, Tenn., extension of revetment	35,000
Memphis, Tenn., repair and preservation of revetment	10,000
Helena, Ark., extension of revetment	30,000
Greenville, Miss., rectification of banks	100,000
Total	1,983,333

The appropriation in the sundry civil act of March 3, 1899, amounted to $2,583,333, which was allotted as follows:

Mississippi River Commission	$35,000
Surveys, gauges, and observations	70,000
Dredges and dredging	358,400
Experimental low-water dikes	50,000
Plum Point Reach, repair and preservation of works	60,000
Hopefield Bend, repair and preservation of works	60,000
Plant, repairs and renewals, first and second districts	25,000
Surveys, first and second districts	5,000
Ashbrook Neck, repair and preservation of works	20,000
Lake Providence Reach, extension and repair of bank revetment	60,000
Plant, repairs and renewals, third district	60,000
Surveys, third district	5,000
Kemp Bend Bank Revetment	180,000
Plant, repairs and renewals, fourth district	64,444
Surveys, fourth district	5,000
Levees	1,250,000
Hickman, Ky., repairs to revetment	6,000
Greenville Harbor, Mississippi, repairs to revetment	26,000
Bondurant, La., bank protection	10,000

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The sundry civil act also specifically provided for the expenditure of the sums named at the following points:

New Madrid, Mo., extension of revetment	$40,000
Caruthersville, Mo., rectifying the banks	35,000
Helena, Ark., improving harbor and rectifying banks	30,000
Greenville, Miss., rectifying banks	50,000
In hands of President, reserved for allotment	78,489
Total	2,583,333

The river and harbor act of March 3, 1899, provided for the expenditure of the following amounts under the direction of the Mississippi River Commission:

Harbor of Natchez and Vidalia, Miss. and La	$50,000
Harbor of New Orleans, La	110,000
Rectification of Red and Atchafalaya rivers, Louisiana	25,000
Total	185,000

MISSISSIPPI RIVER COMMISSION.

At the first meeting of the commission, held in Washington, D. C., August 19, 1879, it was resolved "that the permanent headquarters of the commission be at St. Louis, Mo." This resolution is still in force, and at the present time the office is located in the Fullerton Building and is in charge of the secretary of the commission, Capt. Mason M. Patrick, Corps of Engineers, U. S. A.

There have been five sessions of the commission during the year. Two of these have been held on board the steamer *Mississippi* en route from St. Louis to New Orleans for the purpose of inspecting the river and the improvement works. The sessions were held on the following dates: Seventy-third session, June 16–18, 1898, at Army Building, New York City; seventy-fourth session, December 3–11, 1898, on steamer *Mississippi*, St. Louis, Mo., to New Orleans, La.; seventy-fifth session, March 7–9, 1899, at Army Building, New York City; seventy-sixth session, April 26 to May 2, 1899, on steamer *Mississippi*, St. Louis, Mo., to New Orleans, La.; seventy-seventh session, June 19–21, 1899, at Army Building, New York City.

The committee on dredging have held one meeting in St. Louis, and visited the dredges operating under the direction of Major Handbury, near Crystal City, Mo.

Since the last annual report, changes have been made in the personnel of the commission due to the death of Henry Flad, which occurred on June 20, 1898. On August 12, 1898, J. A. Ockerson was appointed to fill the vacancy.

Removal of sand bar in front of the city of Memphis, Tenn.—The river and harbor act of March 3, 1899, provided that "the Mississippi River Commission is directed to examine the harbor at Memphis, Tenn., and report what improvement, if any, should be made to remove the bar in front of the city of Memphis, together with the cost thereof."

To comply with this provision of the law, the commission has made a special examination of the harbor of Memphis and given the subject of its maintenance and improvement careful consideration. During a recent tour of inspection of the river a number of the citizens of Memphis appeared before the commission and expressed a desire for the removal of the accretions that have recently been deposited below the mouth of Wolf River and in front of the upper portion of their steamboat landing.

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In order that the conclusions of the commission and its recommendations in this matter may be clearly understood, a brief statement of the conditions that have prevailed here during recent years would seem to be necessary. This locality, like all others along the river, has been subject to periodic changes.

It is of record that the left bank of the river at one time prior to 1867 was close into the bluff near the foot of Jackson street, in the city of Memphis, and that the mouth of Wolf River was in this vicinity. In 1867, we find that accretions had taken place, probably owing to some change in the river above, until the bank of the river was fully 1,000 feet farther toward the Arkansas shore. This land was known as the United States Navy-Yard. It remained in practically the same condition until about 1873, when it began gradually to fall into the river. In 1876 it had receded 350 feet, and was caving in at the rate of 100 feet per year.

Under authority from Congress, a project was proposed for revetting the river bank in this locality for a distance of 7,600 feet. Two thousand of this was above the mouth of Wolf River and 5,600 feet below. The work was commenced under an appropriation of $46,000 made by the river and habor act approved June 18, 1878. Additional appropriations and allotments were made for this work, and it was completed under the project from Wolf River down as far as the foot of Jefferson street in February, 1883, the aggregate amount expended being about $148,000. During the high water of 1884 much of this revetment was undermined, and the whole of the upper portion of the city front placed at the mercy of the eroding action of the water. Since that year a new project for the protection of the city front has been carried out. The whole distance from the mouth of Wolf River down to the Kansas City and Memphis Railroad Bridge, about 13,400 feet, is now protected. Of this 10,300 feet has been revetted by the United States, 2,200 is protected by a system of low spur dikes put in at the expense of the citizens of Memphis, and 1,000 feet immediately above the bridge was revetted by the railroad company to protect the east pier.

The total cost of this work to the United States has been approximately $450,000.

Soon after the revetment was put in place which protected the upper part of the city front, extensive deposits began to take place in the vicinity of Wolf River, and below as far as Jefferson street. In this locality where there were depths of 100 feet and more in 1884, sand and sediment have been deposited until now the top of the bar is 18 and 20 feet above the surface of the river at low water. The left bank of the river at low and medium stages is fully 2,000 feet nearer the Arkansas shore than it was at that date, and in about the same position that the bar line on that side was at that time. The accretions below the mouth of Wolf River will amount to fully 10 acres, and those above very much more. These are covered with a vigorous growth of willows, and with each overflow at high water the resulting deposits bring their surface nearer the high-water limit.

The changes that have been noted have their origin, of course, at a point higher up the river. There is transmitted herewith a map on which are plotted the bar and bank lines of the river between the upper end of Hopefield Bend and the Kansas City and Memphis Railway Bridge as they existed at various periods between January, 1876, and December, 1898. A study of this is very interesting as showing the intimate connection between the situation at Wolf River and the conditions existing in the Hopefield Bend. The Centennial cut-off

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which took place in 1876, about 25 miles above Memphis, was undoubtedly instrumental in intensifying the gradual change that was taking place in Hopefield Bend. The increased current induced by this caused a much more rapid erosion of the bank in this locality. As the upper part of the bend was thrown in, the current on leaving it at the lower part was deflected strongly against the Tennessee bank in the vicinity of Wolf River, causing the erosion there which necessitated the bank protection above described. As the caving in Hopefield Bend progressed downward, the point of maximum impact and strain upon the revetment work in front of Memphis moved down also, until by the washing away of Hopefield Point the cross section of the river in the vicinity of Wolf River was very much enlarged, and the main current passed down more nearly parallel to the Memphis front. Under these conditions the large deposits took place in the bend at Wolf River and along the upper portion of the city front.

The revetment of Hopefield Bend was commenced in December of 1882, and finished in 1889. During the four succeeding years it was extensively repaired in the lower 10,000 feet. The total length of bank protected is about 16,000 feet. Had the erosion of Hopefield Point not been checked the whole of the city front of Memphis would have been masked by accretions.

The project for this revetment contemplated commencing at the upper end near Mound City and working gradually down, holding the bank in about the position marked on the map "Bank line, 1881." This would have resulted in the ideal harbor for the city of Memphis. Unfortunately, however, the project was met at various stages of its execution with the fact that sufficient funds were not available for properly carrying on the work. As a result of this, before the whole bank could be protected, it had been eroded back nearly 3,000 feet from the projected line, the original site of the town of Hopefield had tumbled into the river, and great damage was done to the railroad interests and property in that locality. Large deposits had also been made in the vicinity of Wolf River.

The expense of this revetment to the Government has been in the neighborhood of $1,100,000, making the total cost to the Government for improving Memphis Reach approximately $1,560,000.

Since 1892, the date on which we may say that Hopefield Bend was made to assume something like stable conditions, there has been no change of any consequence in the bank line in the vicinity of Wolf River, and the upper part of the Memphis front, excepting that the deposits are gradually becoming higher. These are not now overflowed until a 20-foot stage of water is reached, nor do they seem to be extending downstream. The maximum high-water gauge reading at Memphis is 37.66 feet.

We may therefore safely assume the regimen of the river to be practically fixed at this point so long as Hopefield Bend can be held in its present shape. It must be expected that occasional breaks will continue to take place in this revetment. These must be at once repaired and the whole bank line held practically in its present position. It is also apparent that no work should be placed in the river that will in any way change its regimen in this vicinity. An attempt to rehabilitate former conditions would undoubtedly result in a necessity for large expenditures of money which present circumstances do not seem to warrant.

The accreted land, even in its present elevation, is available for wharfage purposes when supplemented with proper structures, and must be of value to its present owners and to the city of Memphis.

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The evident solution of the difficulty is to encourage the building up of the land in this locality, to occupy it with piled structures and to give the present bank from the mouth of Wolf River down a permanent character by protecting about 3,000 feet of it with a good, substantial revetment. It is estimated that this will cost about $150,000. Should the exigencies of commerce or the conditions of the river require it, this revetment might in time be carried above the mouth of Wolf River.

It has been suggested that the bank lines of 1884 might be restored by placing works in Hopefield Bend that would cause deposits there and throw the main current strongly against the Tennessee shore above the objectionable accretions and wash them away; or, that the river might be taken in hand at the foot of the next bend above and thrown into the bed of the Loosa Hatchie, thence down to the Wolf River, and by that down to its present channel past Memphis.

It is very doubtful if either of these plans could be successfully carried out. In both cases the first cost and the expense of maintenance would be excessive and far out of proportion to any advantages that would be gained. In view of the above facts, it is the sense of the Commission that "No improvement should be made to remove the bar in front of the city of Memphis."

Quarantine restrictions.—The rigid enforcement of quarantine regulations owing to the prevalence of yellow fever caused serious delay and inconvenience in the prosecution of all work of the Commission lying below Cairo. In the lower districts it practically caused a suspension of work during the season most favorable for effective operations, and as a consequence of the interruptions and delays the cost of the work was much higher than usual.

SURVEYS, GAUGES, AND OBSERVATIONS.

This work, together with dredges and dredging, is in charge of the secretary of the Commission, with headquarters at Fullerton Building, St. Louis, Mo. The position was filled by Capt. H. E. Waterman, Corps of Engineers, United States Army, up to the time of his death, which occurred on October 26, 1898. Capt. Mason M. Patrick, Corps of Engineers, United States Army, was assigned to this duty on October 29, 1898, and has continued in charge since that date.

Field work.—During the summer of 1898 the secondary triangulation and precise levels were extended northward from St. Paul, Minn., to Aitkin, Minn., a distance by river of about 210 miles. The field work began on June 1 and ended on November 15, 1898. The mean closure of 101 triangles measured during the season was 1.14 seconds. Of these triangles 48 had an average closure of 1.17 seconds large and 53 triangles closed 1.11 seconds small. The line of precise levels was carried up the left bank of the river, with the exception of a short stretch from Brainerd northward. Standard tile and pipe bench marks were established at intervals of about 3 miles. The bench marks and corresponding marks on the right bank were located trigonometrically.

These marks, in connection with the main points in the triangulation system, form the base for the topographical and hydrographical surveys and are valuable as accurate initial points for all future surveys. They make it practicable to determine with accuracy the changes in location or elevation of the bed of the stream that may occur in the future. For details of this work see Appendixes 1 A and 1 B.

The topography and hydrography of this portion of the river was begun on May 8, 1899, and is now in progress from St. Paul, Minn., northward.

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Mapping, etc.—The office reduction and platting of field notes of surveys have been continued. During the year ten charts (161 to 170, inclusive), scale 1:20,000, covering 68 miles of the river from near Dubuque, Iowa, to Genoa, Wis., have been completed. Progress has been made on five other charts extending up to near Winona, Minn.

Charts 158 to 162, inclusive, have been published. This completes the published series to a point 632 miles above Cairo. Charts 163 to 170 are now in the hands of the printer.

Sheets 125 and 126, inch-mile, have been completed, and progress has been made on sheets 127 and 128, extending about 720 miles above Cairo. Sheets 123 and 124 have been published, and sheets 125 and 126 are in the publishers' hands.

Sheets 3 and 4 of the Upper Alluvial Valley map have been completed and are now in the hands of the publishers.

The Lower Alluvial Valley map has been revised and a new edition has been published.

Gauges.—The permanent gauges of the commission have been maintained during the year. There are fourteen gauges on the Mississippi River, one on the St. Francis River, one on the White River, one at the head of the Atchafalaya River, and a self-recording tide gauge at Biloxi, Miss.

The high-water gauges, 182 in number, were also maintained. These are placed along the river at intervals of about 5 miles, from Cairo, Ill., to the forts below New Orleans.

Stage.—The stage of river during the year has been marked by frequent oscillations, even throughout the low-water months. On August 19, 1898, the river reached a stage of 27.3 feet at Cairo, the crest reaching Helena, Ark., on August 22, with a gauge reading of 26.7 feet. The lowest stage was reached in October, at a reading of 7.7 feet on the Cairo gauge, and 4.6 feet on the Memphis gauge.

The stage of river was favorable to navigation throughout the low-water season, which covered the period from September 1 to the latter part of December, when a rapid rise set in. During the greater part of the month of November the water stood above the 15-foot stage at Cairo.

The first flood wave reached a stage of 38.3 feet at Cairo on January 19, 1899. This wave reached a stage of 38.6 feet at Helena and 40.6 feet at Arkansas City.

The next wave reached a maximum of 46.2 feet on the Cairo gauge on April 2. It remained nearly stationary at Cairo from March 17 to April 9, being above danger line for a period of thirty-eight days. The crest of the wave reached Helena with a maximum of 46.7 feet, 48.6 feet at Arkansas City, and 47.3 feet at Vicksburg. Both flood waves passed off without any serious results.

Mean Gulf level.—A self-registering tide gauge has been in continuous operation at Biloxi, Miss., for a period of forty-five months. The record is an exceptionally good one, and a final value for mean Gulf level at Biloxi, Miss., can now be given. This value, deduced from the monthly means of 1882, 1884, 1896, 1897, and 1898, reads 6.083 feet on the staff gauge at Biloxi. It is 0.318 foot lower than the privisional value heretofore used. For further information on this subject, see Appendix 1.

Discharge measurements.—As the stage of river during the year did not reach very near the limits of either high or low water, no discharge measurements were made in the main stream. A discharge measurement was made of the St. Francis River at a stage about 8 feet above low water.

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Special surveys.—In order to ascertain what changes occur in the bed of the stream, surveys were begun in October, 1894, at the mouth of the Arkansas River and covered the river to Vicksburg. During the winter of 1895–96 these surveys were extended from Vicksburg to Donaldsonville. In the winter of 1897–98 the reach from Scot Bluffs, a short distance above Baton Rouge, to Donaldsonville, was resurveyed, and the work extended to Carrollton.

A full discussion of the results will be found in the reports of the Commission for 1896, page 3577; 1897, page 3672; 1898, page 3241, and in Appendix 1 of this report.

This investigation covers the river from near the mouth of the Arkansas River to Carrollton, La., a distance of 558 miles. From the mouth of the Arkansas River to Donaldsonville, La., a distance of 486 miles, 1,772 complete cross sections of the river have been compared with similar cross sections made by the general survey of the river in 1882–83, after a lapse of from eleven to fifteen years. These sections average about one-fourth of a mile apart, and about 150,000 elevations of the river bed have been determined.

When the general survey of the river was made permanent bench marks were established at short intervals. The elevations and positions of these marks were carefully determined, and they formed the base of the survey from which the elevations of the water surface were determined.

Having the elevation of the water surface at each section and the depth of water it is very easy to deduce the elevations of the bed of the stream.

The same marks have been used in the special survey to deduce the elevations of the bed of the river, and the results have been carefully compared with those of the earlier surveys.

It is a well established fact that the elevation and capacity of the bed of the stream is constantly changing, and that these changes are closely related to changes in stage. There are also changes due to local causes. It is evident, therefore, that the resultant effect of these changes on the general condition of the bed can only be determined by studying the changes in a long stretch of river through a considerable period of time.

Even then the problem is a very complicated one, owing to the impracticability of making the surveys under the same conditions of stage. The best results would require that the stages of the surveys to be compared be the same; that they should be made at the same interval of time after a flood of the same duration and height.

While these desirable conditions are impracticable of attainment, it is believed that the general tendency is well expressed in the extensive investigation that has been made and which is discussed in detail in the reports above referred to.

The results may be briefly stated in the following terms:

From the mouth of the Arkansas River to Vicksburg, a distance of 200 miles, the area or size of channel was found to have increased an average of 3.2 per cent. The bed of the river on the crossings or bars was found to be lower, and in the pools it averaged higher, than when the first survey was made; the mean depth was found to have increased for 119.6 miles, and decreased for a distance of 80.4 miles, and the maximum or thalweg depth increased for 86.4 miles and decreased for a distance of 113.6 miles. On the whole the channel capacity was found to be larger, this increase being largely due to cutting down the bars and increase in width.

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From Vicksburg to Scot Bluffs, a distance of 214 miles, the first survey was made during the fall and winter following the great flood of 1882. The special survey was made in the fall and early winter of 1895–96, during an unusually low stage of river and after two consecutive seasons of low-stage conditions. The results derived from a comparison of these two surveys, made under such widely different conditions, are as follows: The channel shows increased capacity, due mainly to changes above the medium-stage line; the last survey shows the mean depth to be greater for a distance of 72.2 miles, while for a distance of 142.8 miles the mean depth is less than it was when the first survey was made; the maximum or thalweg depth shows an increase for a distance of 93.1 miles and a decrease for a distance of 120.9 miles. These differences mainly occur in that portion of the river lying below Natchez. Above Natchez the maximum depth showed an increase for a distance of 46 miles and a decrease for a distance of 41.8 miles.

The general survey from Scot Bluffs to Donaldsonville, a distance of 58.1 miles, was made in the winter and spring of 1883 during a rapidly rising and high stage of river following the flood of 1882. The first special survey of this reach was made at the lowest stage of river known and after two seasons of unusual low-stage conditions. Under the latter conditions the water surface had very little slope, and the sediment that reached this portion of the river was doubtless deposited in the bed of the stream. A comparison of the conditions shown by the surveys of 1883 and 1895 gives the following results: An increase in the channel capacity above the medium-stage line; the bed of the river on crossings shows an average decrease of mean depth of 1.4 feet and an average increase of mean depth of 0.5 foot in pools; the mean depth has increased for a distance of 26.2 miles and decreased for a distance of 31.9 miles; the maximum depth has increased for a distance of 14.4 miles and decreased for a distance of 43.7 miles, and the average decrease in maximum depth amounted to 6.6 feet. This marked decrease in thalweg depth was thought to be due to an engorged condition of the stream caused by a long period of low-stage conditions. In order to verify this view of the situation another survey was made during the fall following the extraordinary flood of 1897. In comparing this survey with the special survey made prior to the flood of 1897 use was made of 391 cross sections and 26,052 elevations of the river bed. The results are very decided and show plainly that the flood of 1897 swept out the engorgement above referred to and went even further. The average increase in cross section amounted to 3.7 per cent, and the average increase in thalweg or maximum depth was 3.6 feet over that of 1895. As compared with the conditions existing in 1882 it shows an average increase in cross section of 2.2 per cent, and an average increase of maximum depth of 1.2 feet. It is altogether probable that further investigation would have developed similar results, perhaps in diminishing proportions, from Scot Bluffs northward.

From Donaldsonville, La., to Carrollton, La., a distance of 73 miles, the results obtained by comparing 489 cross sections, derived from 31,416 elevations pertaining to the surveys of 1893 and 1897, show an average increase in cross section of 1.1 per cent and an average increase in thalweg or maximum depth of 2.1 feet.

As further evidence of the enlargement of the bed it may be noted that while the flood of 1898 was 1.8 feet lower than the flood of 1897 at Cairo, 2.6 feet at Helena, 1.4 feet at mouth of White River, and 0.2 foot at Lake Providence, it passed Red River Landing and points below, where the levees were held in 1897, at a stage of about 6 feet below that of 1897.

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In the Commission reports of 1895, page 3624, and 1896, page 3428, will be found further data bearing on this subject, which are deduced from low-water gauge readings.

In the Commission report of 1890, page 3093, will be found a full discussion by Gen. C. B. Comstock as to whether levees along a river cause its bed to rise, with particular reference to the results on the Po and Yellow rivers.

All of the available data deduced from the special surveys point to an enlargement of the cross-sectional area of the stream below the high-water banks, and 57 per cent of the length of river under consideration shows a decided depression of the bed even under dissimilar and unfavorable conditions of comparison.

These investigations give no evidence of a general progressive elevation of the bed of the stream, but do justify the belief that with the banks properly revetted to prevent erosion the ultimate effect of confining the floods by means of levees will be a depression of the river bed and consequent enlargement of channel capacity.

DREDGES AND DREDGING.

In the fall of 1891 the Commission took up the study of suitable means for the temporary relief of commerce, pending the extension of the work for the permanent improvement of the channel.

The various devices designed for the ready removal of obstructing sand bars were carefully considered, and the conclusion was reached that hydraulic dredges of large capacity gave the greatest promise of success. The first of these dredges was ready for actual work in the fall of 1894. (See Commission reports 1893, p. 3557; 1894, p. 2715.) During the season of 1898 five dredges, with a combined working capacity of at least 5,000 cubic yards per hour, were in operation. The dredge *Beta* was undergoing repairs and was not available for work.

These dredges are designed with a view to cutting rapidly through the low-water bars which temporarily obstruct navigation, thus inducing the current to follow the path of the dredge to such an extent as to enlarge the cut and maintain a satisfactory channel.

The dredging plant at the beginning of the fiscal year consisted of six dredges, two towboats, three pile sinkers, and a number of fuel and other barges.

The steamer *Search* and quarterboat *Illinois*, with their equipment and a fuel barge, pertaining to "Surveys, gauges, and observations," have been transferred to "Dredges and dredging," as they are no longer needed for the general survey work.

Extensive repairs were made to the machinery of the dredge *Beta*. The cutter machinery was replaced by jet agitators, and new hoisting and hauling engines were put in. The hull was widened 18 feet, so as to reduce the draft to about 4½ feet.

A contract was made with the Springfied Boiler and Manufacturing Company, of Springfield, Ill., for the construction of the seventh dredge, *Iota*, at a cost of $98,820. This is a steel-hull dredge, with machinery of the same general design as the *Epsilon* and *Zeta*. Side wheels and propelling engines are provided, so that the boat can move from point to point with its own power. The discharge pipe will differ from the form heretofore used. It will be carried entirely above water on pontons, in order to facilitate the deflection of the pipe line when it becomes desirable to discharge the material outside of the dredged channel. It is expected that this dredge will be completed ready for use during the

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coming low-water season. Full specifications for the dredge will be found in Appendix 1, submitted herewith.

Arrangements have also been made for the construction of the eighth and ninth dredges, *Kappa* and *Lambda*, on substantially the same lines as the *Iota*. Bids for these dredges were opened on May 31, 1899, and the contract was awarded to the Bucyrus Company, South Milwaukee, Wis., the price being $244,800 for the two dredges.

A contract for the construction of five large, steel-hull towboats, to be used as dredge tenders, was awarded to the Iowa Iron Works, Limited, of Dubuque, Iowa, for the sum of $45,672 each.

Considerable progress has been made under this contract, and it is probable that some of the boats will be available for use during the low-water season of 1899. For detailed description of these boats, see Report of Commission for 1898, page 3196.

Three small, steel-hull steam tenders have been constructed during the year by M. A. Sweeney Company, of Jeffersonville, Ind., at a cost of $7,749 each. They are to be used in connection with the dredges in making surveys and moving pile sinkers, fuel flats, etc., as may be required. A full description of these boats will be found in Report of 1898, page 3190.

Four wooden-hull pile sinkers were constructed by The Cincinnati Marine Railway Company, of Cincinnati, Ohio, at a cost of $1,684 each for the hulls and leads. The machinery for them was obtained from dismantled pile drivers which had been used on dike work in the first and second districts.

All of the dredging and other plant was cared for at West Memphis, Ark., and was put in thorough repair while out of commission.

During the season of 1895, from September 12 to December 4, with one dredge, the *Alpha*, at work, the navigable depth was increased at Cherokee 3.6 feet, at Sam Phillips 1.7 feet, at upper Point Pleasant 3.5 feet, and at Medleys 2.1 feet.

During the season of 1896 the *Alpha* and *Beta* were in commission from August 28 to November 30. Eight bars were dredged and the navigable depth was increased from 1 to 4 feet.

In 1897 three dredges, *Beta*, *Gamma*, and *Delta* were in commission from September 1 to about the middle of November, and one, the *Alpha*, from October 12 to November 28. Work was done on fifteen bars between Cairo, Ill., and Graves Bayou, which is 250 miles below Cairo. This dredging resulted in an increased depth of from 1.5 to 5 feet, and at the lowest stage of the season there was a navigable depth of 8 feet or more from Cairo down.

The dredging plant was too small to meet all of the demands made upon it. The bars developed so rapidly and at so many different points that shoal water developed for a short time at several crossings before the dredges were able to reach them; but these shoals very generally yielded when the dredges attacked them.

With the exception of the work done in the vicinity of Point Pleasant, where the channel depths were at times as low as 6 to 6½ feet, from September 20 to November 10, the results of the dredging may be considered as satisfactory. Nearly all of the bars dredged showed marked improvement throughout the entire season.

By the low-water season of 1898 the fleet of serviceable dredges had been increased to five by the addition of the *Epsilon* and *Zeta*. They were put into commission on September 3, 1898, and continued, with several suspensions due to high stage of river, until the latter part of December.

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Five large towboats were chartered for use as tenders to the dredges.

Careful surveys were made during the declining stage following the high water of 1898 of all crossings which gave promise of becoming troublesome to navigation. These surveys are valuable not only for the purpose of indicating what bars require dredging, but also for the purpose of aiding in the determination of the proper location of the cuts to be made.

Surveys were also made after dredging was completed to show what had been accomplished by dredging and how well the dredged channels were maintained. A comparison of the conditions existing before and after dredging gives a good measure of the work accomplished.

The season was marked by a succession of pulsations in stage, some of which rose to such a height as to cause temporary suspension of the work. Such conditions are very unfavorable for dredging. The lowest stage reached at Cairo during the low-water season was 7.7 feet, and at Memphis 4.6 feet, while from October 23 to December 20 the stage ranged from 10 to 20 feet on the Cairo gauge and from 5 to 13 feet on the Memphis gauge.

Dredging was done at the following bars: Upper Point Pleasant, Sam Phillips, Lazelles, Cherokee, Hickmans, Elmot, Island 34, Island 40, and Fleeces and Wilsons Point. While the season throughout was decidedly unfavorable for good results from dredging, it can be said that the work at all of these bars resulted in deepening the channel from 2 to 4 feet. In a few cases the channel dredged was obliterated by a rise in the river. In most cases the effect of dredging was apparent until the end of the season. Experience in dredging thus far indicates that if the cut across the bar is properly located, it will be maintained and will probably enlarge to a certain extent until the channel conditions are materially changed by an increasing stage of considerable magnitude.

Efforts were made to fill up side chutes at Point Pleasant, Island 34, Island 40, and Peters Towhead. These efforts were only partially successful, owing to fluctuations in stage and prevalence of rising stage conditions.

Eight of the bars which required dredging lie between Cairo and Memphis; the other three lie below Memphis—one 15 miles, one 40 miles, and one 300 miles.

The work at Island 40 was especially difficult, owing to the presence of sunken logs and trees which were embedded in the sand. In opening this channel 54 logs were removed. They ranged from 8 to 50 inches in diameter, with an aggregate length of over 1,500 feet.

During the season the actual dredging time for one dredge amounted to 107.3 days. The time spent in repairs amounted to 26.9 days. The dredges were in commission, but idle, 178.3 days, while waiting for suitable stage conditions.

It is well to note that during the low-water season of 1898 only eleven bars between Cairo and Vicksburg showed sufficient shoaling to justify dredging.

Capacity tests were made of three of the dredges under ordinary working conditions. For this purpose places were selected where there was no current to bring in sediment and where the output of the dredge for a considerable period of time could be determined by measuring the bar before and after dredging. The *Gamma* dredged forty-five and one-half hours and removed 45,856 cubic yards of sand through 1,000 feet of discharge pipe. This gives an average of 1,008 cubic yards per hour.

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The *Delta* test continued twenty-seven hours and twenty-three minutes, and gave an output of 34,462 cubic yards delivered through 1,000 feet of discharge pipe, or an average of 1,259 cubic yards per hour.

The *Epsilon* delivered 32,407 cubic yards of sand through 1,000 feet of discharge pipe in twenty-four hours and fifty minutes. This gives an average of 1,305 cubic yards per hour.

The *Gamma* and *Zeta* were also tested as to the practicability of dredging through a dry bar. The *Zeta* cut into the dry bar about 500 feet. The bar stood about 4 feet above water and the suction reached 16 feet below the water, leaving a working face about 20 feet high, which was successfully attacked by the dredge.

For further details concerning dredges and dredging, see Appendix 1 H hereto.

CHANNEL WORKS AND BANK REVETMENT IN THE SEVERAL DISTRICTS.

Works above Cairo.—Headquarters at custom-house, St. Louis, Mo., Maj. Thomas H. Handbury, Corps of Engineers, U. S. A., in charge to March 21, 1899; Capt. Edward Burr, Corps of Engineers, U. S. A., in charge from March 21, 1899.

The river and harbor act of July 5, 1884, appropriated $50,000 for the purpose of extending the revetment work which had been put in to check the bank erosion in the rear of Cairo, Ill., the work to be done under the direction of the Mississippi River Commission.

In September, 1884, a mattress 120 feet wide and 4,628 feet long was put in and the paving was repaired.

Further repairs were made in 1885–86, where the work was damaged by ice, and a mattress 120 feet wide and 500 feet long was placed between spurs 3 and 4 in the fall of 1886.

In November, 1898, 602 linear feet of repairs were made to the stone work between the spur dikes at Eliza Point. This was done at a cost of $1,200, leaving an unexpended balance of $7,400. The work at this point has been entirely successful and no extension is contemplated at present.

First district, Cairo, Ill., to foot of Island 40, 220 miles.—Headquarters at 36 Equitable Building, Memphis, Tenn. District officers: Capt. Mason M. Patrick, Corps of Engineers, United States Army, to December 5, 1898; from December 5, 1898, Capt. E. Eveleth Winslow, Corps of Engineers, United States Army.

Construction works for channel improvement and for the protection of caving banks in this district are located at Columbus, Ky., Hickman, Ky., New Madrid, Mo., Caruthersville, Mo., and throughout Plum Point Reach. Some work was also done with experimental dikes opposite Point Pleasant, Mo.

Columbus, Ky., 21 miles below Cairo.—The work at this harbor was done in 1889 and 1890 under special appropriations, for the purpose of preventing further encroachments of the river on the banks in front of the town. The object was attained by the construction of submerged Spur Dikes 1, 2, 4, and 5, and a foot mat for Dike No. 3, which was never completed, owing to the appropriation being exhausted. The work covers about 2,200 feet of river front and is still in fairly good condition. At the present time there is no apparent necessity for further work.

Hickman, Ky., 36 miles below Cairo.—The work at this point consists of 1,560 feet of continuous revetment, which was put in to prevent

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caving along the lower portion of the town. Special appropriations were made for this purpose in 1886 and 1888. In 1889 some 970 feet of the work was put in. In 1892 a layer of riprap stone 10 inches thick was added to the revetment above the low-water line, and a pocket mat was sunk at the lower end to prevent further scour at that point. In 1894 some additional repairs to the old work were made and new work was put in amounting to 630 feet in length. No serious changes in the bank line have occurred since this revetment was completed. A break in the upper bank paving has recently occurred near the upper end of the work of 1894 and repairs will be required in the near future.

New Madrid, Mo., 71 miles below Cairo.—The work here has been done under special appropriations, the purpose being to prevent the banks from caving along the river in front of the town. This has been accomplished by a continuous revetment of the fascine type of mat 250 feet wide below low water and riprap paving on a graded bank above low water. The work began in 1893 and 900 feet in length was completed. During the following year the work was extended 700 feet. In 1896 a further extension of 500 feet was made. In 1898 the revetment was extended downstream 1,218 feet and upstream 355 feet, making a total length of 3,643 feet of bank which is now protected. This work is all in good condition. A further extension of about 1,000 feet is contemplated.

Caruthersville, Mo., 110 miles below Cairo.—The work at this point is carried on under special appropriations for the purpose of preventing further encroachment of the river along the front of the town. The project contemplates the construction of submerged spur dikes placed at suitable intervals on foot mats extending out 220 feet from the low-water shore line. In December, 1898, four foot or sill mats were built and sunk in place and considerable grading and paving was done. Running ice caused a temporary suspension of the work. On January 6, 1899, the construction of Crib No. 1 of Dike No. 4 was begun. Rising river and accumulation of drift made this work very difficult, and in sinking the crib some of the mooring cables parted and the entire plant was carried away, but was recovered uninjured. The crib reached the bottom somewhat out of line with the position intended for it. Owing to the high stage of river further work was postponed until after the flood stage had passed. A continuation of this work as far as the funds will permit is contemplated. This will provide ample protection for the river front of Caruthersville.

Plum Point Reach, 147 to 186 miles below Cairo.—The work done in this reach extends from the upper side of Daniels Point to Craighead Point, a distance of about 20 miles. It is carried on under allotments from appropriations made for the general improvement of the river. The details of this work will be found in previous reports of the commission. It comprises about 67,400 linear feet of revetment for the protection of caving banks, the closure of the chutes behind Elmot Bar and Island 30 with pile dikes and a brush and stone dam, the closure of Osceola and Bullerton chutes with pile dikes, and a levee along the left bank to confine the flood waters more closely to the river bed. The object of all these works is to increase the navigable depth at low water of a reach of river that had been noted for years for its obstructing sand bars, which were a source of great annoyance and loss to navigation interests.

The result of the work is that the banks have remained fixed within prescribed limits and the navigable depth at low water has been increased to such an extent that little or no difficulty was experienced

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in navigating this reach from 1884, when the works had reached such a stage of completion as to influence the channel conditions, to 1897, when deterioration of works and changes in conditions above the reach caused a shifting of bars that developed two shoal crossings in 1897 and one in 1898. At no time, however, since the works were well under way has the navigable depth reached as low a point as it did nearly every low-water season prior to the date of the rectification works.

The work in this reach is at present confined to repairs to revetment work at Daniels Point, Ashport Bend, Fletchers Bend, Osceola Bar, Bullerton Towhead, and the maintenance of the Gold Dust Dam. The greater part of this work is in good condition. It is described in detail below.

Daniels Point revetment.—The primary object of this work was to maintain a fixed direction of approach to the bend next below, and above the contraction works at Gold Dust. The first work in this vicinity was done in 1889, when 5,300 feet of bank was revetted, beginning at the extreme lower end of a long caving bend and extending upstream. Extensive repairs were made in 1891 and 1892, but all of the breaks were not repaired. In 1893 and 1894 further deterioration continued, until there only remained in good condition about 400 feet at the head and 500 feet at the foot of the original work. Most of the subaqueous work was still intact. Repairs were made in 1895, and the revetment was extended 5,000 feet upstream. In 1896 a break occurred near the junction of the work of 1889 and 1895. This break was repaired by means of three cribs.

No work has been done during the past year and repairs of considerable magnitude are now required.

Ashport Bend revetment.—The erosion in this bend began before the improvement of Plum Point Reach was undertaken by the commission. In order to check it 2,694 linear feet of revetment, consisting of a subaqueous mat 138 feet wide, was put in place near the head of the bend in 1882. In 1890 active caving developed throughout a length of about 15,000 feet. As this bend lies immediately above the contraction works at Gold Dust, and as the position of this bank line is a controlling element in the efficiency of the works below, it was important that further recession should be prevented, and provision was made for the revetment of the entire bend. This work was begun in 1891, and 3,250 feet of revetment was put in. In 1892 the work was extended 8,500 feet. In 1893 and 1894 the work previously done was repaired, and 5,580 feet of revetment, overlapping some 1,600 feet of the lower end of the previous season's work, and extending down to near the Gold Dust dikes, was completed. This last work consisted mostly of fascine mats 300 feet wide, with upper bank paving. The work previously done consisted of the old type of woven mat 200 feet wide for a length of 7,000 feet, and 4,650 feet of mat 240 feet wide. The total length of bank covered by revetment in this bend, including the subaqueous work at the upper end, is about 18,400 feet. With the exception of four comparatively slight breaks, due to crevasses in the adjacent levee and caving where the upper bank paving was omitted, this work is all in good condition. Repairs to these breaks were begun in January, 1899, but work was suspended on account of high water. It will be resumed during the coming season.

Fletchers Bend Revetment.—The recession of the bank in Fletchers Bend, due to caving, amounted to 700 feet per year prior to 1884, when the first revetment work was begun. During that year 5,343 feet of completed revetment and 1,100 feet of subaqueous work was put in place.

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The work was done in two sections, separated by about 5,000 feet of caving bank, which was left to await the removal of sunken timber. Failure of appropriations and the prohibition placed on revetment work caused a suspension of work until 1888, during which interval the lower section of revetment near Elmot was practically destroyed.

In 1888 some 6,300 feet of revetment was added. As an experiment a portion of this work was done in three sections of 1,100 feet in length each, and separated by intervals of 300, 400, and 500 feet of unprotected bank, the object being to reduce the cost to that extent.

In 1891 the old work was repaired and 4,344 feet of new work was placed to fill the gap between the upper work and the experimental section of interrupted revetment.

In 1895 the ends of the detached pieces of interrupted revetment were reenforced with stone groins that overlap the ends of the mats about 10 feet and extend beyond them about 30 feet at the low-water line and 70 feet at the bottom, with a thickness of about 3 feet. At the top of the bank the groins are about 10 feet wide and the paving above the low-water line is about 2 feet thick. A crib dike was also placed in a deep pocket which had formed by the recession of the bank where it had not been protected. The purpose of this dike was to break up the eddy action and prevent further erosion.

In 1896 the revetment was extended downstream 2,605 feet and a crib dike was placed in one of the spaces left by the interrupted revetment in order to prevent further enlargement of a deep pocket which was endangering the ends of the mats above and below it.

The total length of bank covered by the revetment above described is about 19,900 feet. About 1,500 feet of the work at the head of the revetment has been lost by the development of rapid erosion above the work. Two cribs have been put in during the past year to check further encroachment upon the work, and considerable extension upstream above Fletchers Field will be required. Some of this work will be done during the coming season.

Osceola Bar Revetment.—The plans laid down for the rectification of the river through the Plum Point Reach required the closure of the chutes between Osceola Bar and Bullerton Towheads and holding the river side of the bar, which was to form the right bank of the stream. The chutes were successfully closed by means of pile dikes, which induced enormous deposits of silt, which practically obliterated the old channels.

The revetment of Osceola Bar was begun in 1883 and several thousand feet of light work was put in place. In 1890 4,500 feet of revetment was put in from the head of Bullerton Towhead upstream, and in 1891 this was extended 1,000 feet farther upstream.

In 1895 a tendency developed to break through into the old chute between upper and lower Osceola Bars, owing to the decay of the dikes built in 1882 and 1883. This was effectually checked by revetment 3,750 feet long spanning the opening.

During the past year several small breaks and defects in the upper bank paving have been repaired. Nearly all of the revetment on this bar is of the old experimental type, with woven mattress above the low-water line. The willows are badly decayed, and a complete renewal of the upper bank work will soon be required. Caving that has developed above the head of the work will probably necessitate an extension upstream in the near future.

Bullerton Towhead Revetment.—The work of holding this bank line was begun in 1882, when 1,428 feet of revetment was put in around the

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head of the towhead. In 1883 the work was extended 8,000 feet. Repairs were also made to the old work. In 1884 the revetment was extended 500 feet to the foot of the towhead, and extensive repairs were made to the work of former years, some of which had been damaged by seepage from water in a pond back of the work. The total length of the Bullerton revetment was 9,928 feet, most of the subaqueous mats being 100 feet wide.

In 1892 the bar which had served to protect the above work was cut away and the full force of the current swept along the revetment, which soon showed signs of disintegration, owing to the scant width of the mats. It therefore became necessary to reconstruct the entire line. Work was begun in the fall of 1893 at a point 400 feet above the head of the towhead and extended downstream 4,056 feet. A further extension of 5,300 feet was made in 1894. The mats used in 1893 were 250 feet wide; those used in 1894 were 260 feet wide.

This work is all in good condition, and will probably require nothing more than slight repairs during the coming year.

Gold Dust Dam.—The river below Gold Dust Landing was divided into three channels by Elmot Bar and Island 30, and the width in that vicinity was so great that contraction works became necessary. A series of dikes was put in in 1882 and 1883 to close the chute between Elmot Bar and the main shore. Two dikes were added in 1889 and 1890. While these dikes were effective in causing heavy deposits of sediment in the chutes, they proved to be too light to withstand the strain put upon them by the floods, which brought down large masses of drift and ice. It was therefore found to be necessary to reenforce them, and in 1893 a substantial brush and stone dam was begun, extending from the main shore to Elmot Bar. As completed in that year, the dam was 3,000 feet long and 13 feet high at the deepest point. It settled considerably, and two breaks occurred in it in 1894, which were repaired during the same year, and the dam was also raised to the 14-foot level.

The dam has continued to settle, and the brush work where exposed shows signs of decay. It is proposed to raise it to the height originally contemplated, which was 16 feet above low water, and to pave the slopes with stone to prevent further destruction of the brush work.

For full details concerning channel works and bank revetment in the First District attention is invited to Appendix 2.

Experimental dikes.—In the temporary improvement of low-water navigation it is sometimes desirable to collect the water which is divided into several incipient channels and cause it to flow through a single channel. For this purpose it has been decided to test some simple forms of dike which can be put in rapidly at small cost and which will not be a serious obstruction to navigation even if left in the channel.

During the fall of 1898 a site was selected along the bar opposite Point Pleasant, and 490 feet of Dike No. 1 and 982 feet of Dike No. 3 were constructed. No plant was available for this work until late in the season, and high water and running ice prevented the completion of the project. Enough work was done to demonstrate that such dikes can be built and placed quite rapidly and at a cost of less than $3 per linear foot, and that they are effective in quickly causing large deposits of sediment.

Further experiments on the same lines are contemplated during the coming season.

For full details of the work with experimental dikes attention is invited to Appendix 2.

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Second District, foot of Island 40 to mouth of White River, 180 miles.—Headquarters at 36 Equitable Building, Memphis, Tenn. District officers: Capt. Mason M. Patrick, Corps of Engineers, United States Army, to December 5, 1898; from December 5, 1898, Capt. E. Eveleth Winslow, Corps of Engineers, United States Army.

Works for the improvement of the channel and for the protection of caving banks in this district are located at Hopefield Bend, mouth of Wolf River, Memphis Harbor, Nonconnah Rock, and Helena Harbor.

Hopefield Bend, 227 to 230 miles below Cairo.—This work consists of about 16,000 feet of bank protection, which covers the entire bend from Mound City Landing to Hopefield Point. It was done to prevent the rapid recession of the bank, which had been going on for some years and threatened to destroy navigation along the harbor front of Memphis. This work has been done under allotments from appropriations for the general improvement of the river.

The revetment was begun in December, 1882, at Mound City Landing, and was continued, with the usual interruptions caused by high water, until June, 1885, up to which time about 10,000 feet of bank had been revetted.

Repairs were made in 1886, and in 1887 the work was extended downstream 4,000 feet. In this work the width of the subaqueous mats was increased to 335 feet. The width of the earlier mats used was 140 feet.

Lack of funds prevented the extension of the work in accordance with the plans first laid down. As a consequence, before it could be completed Hopefield Point, below the revetment, receded about half a mile beyond the line which it was intended should be held. The result of this was a shoaling in the upper part of Memphis Harbor which has caused serious injury to the shipping interests of that port. From 1882 to 1888 Hopefield Point receded, from caving, a distance of 3,000 feet.

In 1889 the revetment was extended down to the end of the point, and repairs to the old work were made.

The revetment now covers a length of about 16,000 feet. It has been repaired from time to time as required. Considerable damage was caused by the high water of 1898, which undermined the bank paving and scoured out holes at the junction of the mat and bank work. Some of these breaks were repaired during the past year by means of new mats and cribs, and the banks were repaved. Further repairs of considerable extent are required, and the entire line must be held in order to preserve navigation along the harbor front of Memphis.

For further details concerning the work in Hopefield Bend attention is invited to Appendix 2.

Mouth of Wolf River, 230 miles below Cairo.—This work is done under a special appropriation, and consists in the improvement of the entrance to Wolf River, which flows through a bar 2,100 feet wide to its junction with the Mississippi River. The channel through this bar and above was obstructed by sunken logs and snags and the accumulation of sediment caused thereby.

Work was begun under contract in September, 1897, and resulted in the removal of 29,638 cubic yards of material in about two months. Many unforeseen difficulties were met with and the contract was terminated.

In July, 1898, a dipper dredge was purchased, and work was resumed with hired labor. About 28,000 yards of material and 90 logs and snags were removed from the channel.

As the mouth of Wolf River is in slack water at high stages of the Mississippi River, deposits of sediment are expected to occur at such times, and their removal annually by dredging will be necessary.

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For further details concerning the work at mouth of Wolf River attention is invited to Appendix 2.

Memphis Harbor, 229 1-2 to 232 1-2 miles below Cairo.—The work in Memphis Harbor consists in protecting the banks from erosion. It has been done under special appropriations made by the United States, by allotments made from appropriations for the general improvement of the river, by funds supplied by the citizens of Memphis, and by the Bridge Company. About 10,166 linear feet of revetment has been put in by the Government, and a system of dikes covering 2,206 feet of bank was put in with the commission plant and with funds furnished by the citizens of Memphis. Repairs to these dikes were made in 1897. The Bridge Company placed about 2,100 feet of revetment in the vicinity of the east abutment of the bridge.

At the date of the last report there remained a gap of 1,200 feet between the Government revetment and the bridge revetment. This gap was closed in the fall of 1898. The total length of the Government revetment along the Memphis front is now 12,366 feet, and it is all in good condition. The bank in the vicinity of the citizens' dikes shows some signs of weakness, and it is probable that some work will be required to remedy the defects in the near future.

The recession of Hopefield Bend caused a fill along the upper portion of the harbor which has cut off about 1,500 feet of the paved steamboat landing. This subject has received special consideration in another part of this report.

For further details of the work in Memphis Harbor attention is invited to Appendix 2.

Nonconnah Rock, 236 miles from Cairo.—The recession of the Tennessee shore left an obstruction of ferruginous sandstone and cemented gravel, which became so dangerous to navigation as to require removal. The work has been done under allotments from appropriations for the general improvement of the river.

In 1893 a contract was entered into for the removal of that portion of the rock which interfered with navigation. The effort was not successful, owing to lack of proper plant, and only 335 cubic yards of material was removed when the contract was canceled. In 1896 the work was taken up by hired labor, with plant made especially for the purpose, and with it 2,333 cubic yards of rock were removed. This cut the rock down to 6 feet below low water. The work was resumed in 1898, when 2,314 cubic yards of rock were removed, leaving a depth of 7 feet over the rock at extreme low water. No further work is contemplated.

For details of this work attention is invited to Appendix 2.

Helena Harbor, 306 miles below Cairo.—The object of this work is to prevent the encroachment of the river along the harbor front of Helena, Ark. The work is carried on under special appropriations made for the purpose of protecting the banks. The work was begun in 1889 under a project for 600 feet of continuous revetment and 5 spur dikes, to cover a front of about 3,000 feet. The revetment, 613 feet long, was successfully completed. The two upper dikes were completed and the others were partially completed after serious interruptions by high water and drift.

In 1896 a continuous revetment was put in, extending from Dike No. 4 downstream about 1,600 feet, with a spur dike of brush and stone at the lower end. Repairs were also made to the spur dikes formerly placed. In 1898 the revetment was continued downstream 926 feet, and repairs to the old work were made.

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At the present time 5,036 feet of bank is protected by revetment. Some of this work near the upper end shows signs of failure and will require renewal.

For further details attention is invited to Appendix 2.

Third district, mouth of White River to Warrenton, Miss., 220 miles.—Headquarters at 64 Equitable Building, Memphis, Tenn. District officer, Capt. H. C. Newcomer, Corp of Engineers, United States Army.

In this district the works for the improvement of the channel and the rectification of the banks are located at Lake Bolivar Front, Ashbrook Neck, Greenville, Lake Providence Reach, and Delta Point. A brief account of each of these works is given below. Detailed accounts are given in previous reports of the commission.

Lake Bolivar Front, 417 miles below Cairo.—This work is done under allotments from appropriations for the general improvement of the river. It consists of continuous bank revetment, that was put in to prevent the destruction of a large levee across the head of Lake Bolivar, which was threatened by the rapid caving of the adjacent bank. The work was done in 1888 and 1889, when 4,250 linear feet of revetment was constructed. Repairs were made in subsequent years to 1894, and with the exception of a few minor defects in the upper bank paving the work seems to be in good condition and has successfully accomplished the purpose for which it was intended. The length of effective revetment is now about 3,775 feet. No further work other than minor repairs is contemplated.

For full details attention is invited to Appendix 3.

Ashbrook Neck, 446 miles below Cairo.—The work at this point is done under allotments from appropriations for the general improvement of the river. The object of the work was to prevent a threatened cut-off which would have seriously disturbed the regimen of the river for a considerable distance above and below and brought disaster to towns, levees, and other works along the river banks. The work was begun in 1890, when 2,820 linear feet of continuous revetment was placed. During the following year it was extended 4,300 feet; 2,610 feet were added in 1892–93, and 1,475 feet in 1894–95, making a total length of protected bank of 11,205 feet. Repairs were made in 1894 and 1897. A levee 7,300 feet long was built in 1891–92 along the axis of the neck to prevent the surface erosion arising from the rapid flow across the point to the bend below, a distance of only 2,000 feet. This levee was badly damaged during the flood of 1892, but the large accumulations of drift which were left by that flood along the upper side of the neck served to check the current and caused a large deposit of sand. In lieu of rebuilding the levee this drift accumulation has been encouraged by felling trees and filling in with brush.

Repairs to the revetment were made during the past year covering a small break near the middle of the work. High water prevented further repairs. The revetment has been thoroughly effective in checking the erosion, and no extension is necessary at present. About 9,990 feet of the work is still in good condition. In order to maintain it, repairs will be required as defects develop.

For further details of this work, attention is invited to previous reports of the commission and Appendix 3 herewith.

Greenville Harbor, 478 miles below Cairo.—This work has been done under special appropriations and allotments from appropriations for the general improvement of the river, supplemented by funds subscribed by the citizens of Greenville in 1887. It has for its object the rectification of the banks to prevent the encroachment of the river upon the

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town of Greenville, Miss., and also to prevent the destruction of the controlling levee line which protects the Yazoo Basin from overflow.

The recession of the bank in the bend immediately above Greenville amounted to about 4,000 feet from 1882 to 1894. The work began in 1887 along the immediate front of Greenville, the project being to hold the bank in that vicinity by means of ten submerged spur dikes resting on foundation mats and placed about 500 feet apart, leaving spaces of 300 feet of unprotected bank between the spurs. The spurs extended out into the river from 375 to 415 feet. The foundation mats were 200 feet wide and extended about 50 feet beyond the ends of the spurs. The finished spurs ranged from 6 to 24 feet in height. This protection covered about 5,000 feet of bank. The rapid erosion of the bank above Greenville continued, and in order to check it in a measure and save the dike work below a mat 706 feet long by 250 feet wide was sunk in 1888 at a point about 4,000 feet above the upper spur. The necessity of revetting the entire bend had long been apparent, but the funds available at this time would only permit this small amount of work.

In 1889 two additional spur dikes and one pile dike were put in above the original spurs. The caving continued in the upper part of the bend and soon resulted in flanking the upper dikes and finally destroyed them. As soon as funds became available for the continuous revetment of the bend this work was taken up and was carried on during the years 1891 to 1894, during which time 14,137 linear feet of revetment was put in place. Repairs were also made. The flood of 1894 did further damage to the spurs originally built. In 1896 repairs amounting to 677 feet of new revetment were made. Repairs were also made in 1897 and 1898. The high water of 1898 caused serious damage to about 600 linear feet of the revetment at the head of the work, and about 4,000 feet was lost in the body of the work, due to the failure of the subaqueous mats. During the past year extensive repairs have been made. These repairs consisted in placing 3,790 feet of channel-mat 300 feet wide, 1,318 feet of channel-mat 250 feet wide, and 6,300 feet of grading and paving on the upper bank. Ten pocket-mats were made and sunk where the revetment showed signs of weakness. Three small brush and stone dikes were built at the top of the bank to prevent erosion behind the revetment. The work was much delayed during the season by quarantine restrictions, and high water prevented the completion of the repairs.

At present the effective revetment, including the seven spur dikes which are still intact, covers a length of 14,500 feet, nearly all of which is in good condition. It will be necessary to extend the work up stream to cover the damaged portion near the upper end, and also make such repairs from year to year as may be required to maintain the revetment in good condition. For full details of this work see previous reports of the commission and Appendix 3 herewith.

Lake Providence Reach, 517 to 552 miles below Cairo.—The work in this vicinity has been done under allotments from appropriations for the general improvement of the river. This reach presented the most serious obstructions to low water navigation of any portion of the river below Cairo, except, perhaps, the Plum Point Reach. The depths were often as low as 4½ to 5 feet on the crossings. It was therefore selected by the commission as one of the reaches where a project for systematic improvement should be carried out.

The original project provided for the closing of all side chutes; contraction works, for the purpose of giving the low water channel a uniform width of about 3,000 feet, and revetment to prevent the erosion of the banks. Under this project systems of dikes were built along the left bank at Duncansby, Mayersville, Baleshed, and Stack Island, and

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along the right bank at Cottonwood and Elton. The banks were revetted in Louisiana Bend and along the river front of Mayersville Island. The work was begun in 1882 and continued until 1886. Details as to the amount of the various kinds of work done will be found in the report of the commission for 1895, page 3843, and in Appendix 3 herewith.

These works resulted in a decided improvement in the channel depths, but they proved to be much too light to long withstand the ravages of the floods. Revetment was prohibited by Congressional enactment, appropriations failed, and the repairs and extensions deemed necessary to strengthen and hold the work already done could not be made, and in consequence of this the uncompleted works were badly wrecked. Portions of the Baleshed and Stack Island systems of dikes were all that remained of the original work in 1889, when slight repairs were made. The latter was effective in closing the Stack Island chute, which was the main low-water channel when the improvement of the reach began. Portions of these dikes are still in place. Despite the destruction of so large a proportion of the works it was found that they had served a very useful purpose in materially improving the navigation of the entire reach, which still continues much better than it was before the work was begun.

The condition of the works is fully set forth in the reports of the commission of December 28, 1888, page 2593, and June 20, 1889, page 2596.

Louisiana Bend Revetment, 522 miles from Cairo.—Work was actively resumed in 1889. The importance of controlling the approach to the upper end of the reach was recognized from the first, when 12,500 feet of the caving bank in Louisiana Bend was revetted. This work was lost for the reasons already set forth, and its destruction had much to do with the loss of the works below.

On resumption of the work 6,024 linear feet of revetment was put in along the upper part of Louisiana Bend in 1889 and 1890. During the next two seasons the work was extended downstream 11,059 feet. Since 1893 the work in the bend has been confined to repairs to the revetment, especially where it crosses the mouth of Old River. Here seven spur dikes of brush and stone have been constructed to prevent scour behind the revetment at high water. Repairs amounting to about 1,247 linear feet of new revetment were made in 1896 and 1897.

The flood of 1897 developed several breaks in the revetment, the thorough repair of which will require the construction of about 2,900 linear feet of new work. No work has been done during the past year.

The revetment now in place covers a length of about 15,820 feet of bank. No general recession of the revetted portion of the bank has occurred since the revetment was completed.

For further details of this work attention is invited to Appendix 3, submitted herewith.

Lake Providence revetment, 540 miles from Cairo.—The rapid erosion of the bank along the front of Lake Providence threatened to destroy the town and a very large levee which crosses the foot of the lake, the destruction of which would require a long line of levee to be built around the lake. It was therefore decided to hold the bank by means of continuous revetment, and work was begun in 1894. It is done under allotments from appropriations made for the general improvement of the river.

During the working season of 1894–95 about 10,140 feet of revetment was put in. In 1898 the caving above the revetment became so active as to threaten the head of the work. In order to protect it the work

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was extended 300 feet upstream into a pocket formed by the caving. This work was begun in January, 1899, but was suspended on account of high water. Operations were resumed during the latter part of February, and after considerable difficulty a mat was sunk 420 feet long and 290 feet wide. The high stage of river prevented all bank paving.

In order to fully protect the levees which are threatened by the erosion above the revetment, it will be necessary to extend the work upstream and repair the old work. Provision has already been made for an extension of about 2,000 feet.

The estimated length of revetment in good condition at the present time is about 9,800 feet. It has been effective in checking the recession of the bank.

For details of this work attention is invited to Appendix 3, submitted herewith.

Delta Point revetment, 598 miles below Cairo.—In 1876 a cut-off occurred which left the city of Vicksburg on a lake some distance from the river proper. This distance was rapidly increased by the recession of the right bank of the cut-off, now known as Delta Point.

From 1878 to 1881 the point was revetted for a distance of 5,400 feet, and one mattress spur dike and two screen dikes were built to prevent this recession, which threatened the destruction of Vicksburg Harbor. This work was done under the Engineer Department.

In 1882 the work was placed under the supervision of the Mississippi River Commission. From 1882 to 1885 the point was revetted for a length of 5,383 feet. In this work the mats used were from 150 to 175 feet wide.

In 1893 and 1894 the work was extended upstream 1,065 feet, the mats used being 300 feet wide. Repairs to the previous work were also made.

After the flood of 1897 it was found that considerable caving had taken place immediately above and below the work, and an extension of the revetment was needed. Plans were made to extend the revetment about 900 feet upstream and 800 feet downstream during the past year, but the season was not favorable for such work, and it was deferred until the coming year, when it will be taken up. The work in place is doing good service.

A summary of the work done by the commission in the improvement of Vicksburg Harbor is given in their annual report of 1897, page 3728.

The river and harbor act of July 13, 1892, provided for the improvement of Vicksburg Harbor by the diversion of Yazoo River into Centennial Lake, which is now being done by the Engineer Department.

Attention is invited to Appendix 3 for further details of the work at Delta Point.

Fourth district, Warrenton, Miss., to Head of the Passes, 453 miles.—Headquarters at 3232 Prytania street, New Orleans, La. District officers: Maj. J. H. Willard, Corps of Engineers, United States Army, from the beginning of the year until November 30, 1898; Capt. Henry Jervey, Corps of Engineers, United States Army, from November 30, 1898, to March 23, 1899; Maj. George McC. Derby, Corps of Engineers, United Sates Army, from March 23, 1899.

The works for the improvement of the channel and the rectification of the banks in this district include the improvement of the harbor at Natchez, Miss., and Vidalia, La., the improvement at the junction of the Mississippi, Red, and Atchafalaya rivers, and the protection of the banks in the harbor of New Orleans.

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Harbors of Natchez, Miss., and Vidalia, La., 700 miles below Cairo.—This work is located in Giles Bend and consists of a series of spur dikes placed at intervals of 450 feet along the caving bend and a levee constructed along the axis of the neck to prevent surface erosion during overflow stages. It is carried on under special appropriations for the improvement of Natchez and Vidalia harbors, and allotments from appropriations for the general improvement of the river. Its object is to fix the bank lines in Giles Bend so as to prevent a threatened cut-off, which would seriously injure the harbor of Natchez and destroy the town of Vidalia, besides endangering important levees and towns for many miles above and below in consequence of the increased caving of the banks which would ensue.

In 1858 the distance across the neck was about 3 miles. By 1883 the caving had reduced the width to about 6,000 feet. From 1883 to 1897 the erosion in the deepest part amounted to 3,200 feet on the upper side of the point, but a fill 1,300 feet in width occurred on the lower side of the point, so that the bank line has extended over the bend where formerly the water was more than 100 feet in depth. The changes in the relative positions of the caving on the upper side of the point and the filling on the lower side, where at one time it was caving, have been such that the change in the width of the neck at the narrowest point since 1883 has been comparatively slight.

Under the direction of the Engineer Department a project was prepared in 1880 to protect the harbors of Natchez and Vidalia by revetting 2¾ miles of Giles Bend and 6 miles of Marengo Bend, and under that project some work was done in the latter bend.

In 1881 the work was taken up in Giles Bend, where some 4,500 linear feet of bank was covered by a system of open dike work and screens made of sawed lumber and poles, the shore ends of the dikes being reenforced with mattresses. Some of these screen dikes extended out 600 feet from the bank into water 120 feet deep. They were held in place by cribs filled with stone.

The above work was done under special appropriations amounting to $90,000. In 1882 the work came under the jurisdiction of the commission, with an unexpended balance of about $8,000. (See Annual Report of 1891, page 3410.) A project was prepared, but no funds were made available for continuing the work until July 13, 1892, when the sum of $80,000 was appropriated. All of the old work had disappeared long before this time.

The first work decided on was the construction of the levee along the axis of Cowpen Point, as the amount appropriated was not sufficient to commence so extensive a work as the revetment of the bend. Difficulties in getting the right of way for the levee caused delay, and the condemnation proceedings which became necessary were not settled until September 15, 1894. The construction of the levee was begun in October, 1894, and completed in March, 1895. It extends from the bluffs out along the axis of the point for a distance of 19,500 feet, and contains 267,810 cubic yards of earthwork. In 1897 the levee was enlarged by the addition of 86,000 cubic yards of earth, and the exposed end of the levee was protected with rock revetment.

The construction of spur dikes for the purpose of preventing further recession of the banks in Giles Bend was begun in August, 1897, and by January 4, 1898, 15 spurs had been successfully placed. The advent of high water prevented further extension of the work. The upper spur is located near the upper limit of caving, and the work as a whole covers about 7,060 feet of bank. Each spur consists of a foundation mat 150

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feet wide by 300 feet long and 2 feet thick, and 2 cribs 6 by 24 by 200 feet and 6 by 16 by 250 feet, respectively. They are sunk normal to the bank at intervals of about 450 feet. A strip of bank 50 feet wide along the axis of the dike is graded and paved from the low-water line up to about a 35-foot stage. A single line of piles spaced about a foot apart was also driven along the prolongation of the axis of each crib toward the top of the bank. The object of these piles was to check the current and prevent scour along the upper bank. The accumulation of drift against the piling formed so much of an obstruction to the flow that the eddy effect increased rather than diminished the scour, and the piling was therefore cut down. Work was resumed September 8, 1898, and continued, with many interruptions due to quarantine restrictions, until January 31, 1899, when it was entirely suspended on account of high water. During this time a spur was put in between spurs 8 and 9, with upper bank paving of brick 150 feet wide. Sections of mat were also sunk below spurs 5, 6, and 14 and above spurs 5 and 7. These repairs were made necessary by the erosion between the spurs, which had injured the work in several places and even threatened to destroy some of the dikes entirely. Extensive repairs will be made during the coming season by placing a continuous revetment between the spurs below the low water line. A general extension of the work to the lower end of the bend is urgently needed, and ample funds should be provided for that purpose. Full details of the work at Natchez and Vidalia harbors will be found in Appendix 4 attached hereto.

Junction of the Mississippi, Red, and Atchafalaya rivers, Louisiana, 764 miles below Cairo.—The work in this locality has for its objects the limitation and control of the outflow through the Atchafalaya and the improvement of the low-water channels from the Mississippi River to the Red and Atchafalaya rivers. A full description of the locality is given in the Annual Report of 1888, page 2297, and 1892, page 3207. The work consists of a series of sill dams in the Atchafalaya, about 5 miles below its head, and annual dredging in lower Old River during low-water stages. It is carried on under special appropriations and allotments made from appropriations for the general improvement of the Mississippi River.

Work on sill No. 1 in the Atchafalaya was begun in August, 1887. The sill is located about 500 feet below the mouth of Bayou des Glaizes and extends entirely across the stream from one high-water bank to the other, and is normal to the current. The sill was made of willow mattress 3 feet thick, 75 feet wide, and 304 feet long, sunk in place with about 42 pounds of rock for each square foot of surface. The banks were graded and the mattress on the left bank was carried to high-water mark. On the right bank the sill was connected with the levee by two earth embankments paved with stone. The sill as completed is 304 feet wide.

In 1888 a dam was built on this sill, the crest of which was carried up to within 6 feet of low-water mark, the average height being about 15 feet. This dam was made up of alternate layers of willow mattress, hard clay and gravel, with a heavy covering of stone over the top layer. The upper edge of the dam is 20 feet below the upstream edge of the sill. It is 100 feet wide at the base and 30 feet wide on top. This dam reduced the area of the cross section at low water from 15,147 square feet to 4,471 square feet, and at high water from 63,479 square feet to 50,710 square feet.

In 1888–89 Dam No. 3 was constructed at a point about 1,750 feet below Dam No. 1, the material and form of construction being the same

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as employed in the first dam. Minor repairs were made to the dams in 1894.

At the present time it is found that the crests of the dams have settled to a considerable extent, due largely to a compressing of the structure itself rather than sinking into the bed of the stream. The ends of the sills, consisting of willow mats, above the low-water line are badly decayed, but the banks covered by them show no tendency to erosion. An examination of the bed of the stream in December, 1898, shows that the sill dams have been entirely successful in limiting the discharge and checking the tendency to enlargement. The depth of the channel from the head of the Atchafalaya to a point several miles below the dams has remained practically unchanged, with the exception of the scour on the lower side of the dams. If this scour should continue it would very soon injure the dams, and in order to preserve them the sill mats will be widened in the locality where the scour is most active. These extensions will be made during the coming season.

A survey of lower Old River was made during the past winter for the purpose of ascertaining what changes had occurred since 1894 between the mouth of Old River and the head of the Atchafalaya. The mean of all the cross sections, 112 in number, referred to the 35-foot stage at Barbres Landing, shows an average increase in cross sectional area of 942 square feet, or about 4½ per cent. The average depth increased 4.2 feet, or about 17 per cent; the average width decreased 76 feet, or about 10 per cent.

There has been a very marked recession of the right bank of Old River near its mouth, which has amounted to about 900 feet in four years. Aside from this, the changes have not been great enough to require attention at the present time. During the low-water season of 1898 the dredge *Ram* was in the field from August 7 to November 17, and was engaged in actual dredging forty-three and one-half days of ten hours each, during which time 73,800 cubic yards of material was removed. The dredge was idle twenty-eight days while the river was too high to require dredging. A good navigable depth from the Mississippi River to the Atchafalaya and Red rivers was easily maintained throughout the season.

For further details concerning the operations at the junction of the Red and Atchafalaya rivers, attention is invited to Appendix 4 herewith.

New Orleans Harbor, 966 miles below Cairo.—The work is done under a special appropriation made for the improvement of New Orleans Harbor. The original project provided for the protection of about 50,000 feet of bank by means of continuous revetment and spurs. The object of the work is to prevent the erosion of banks along the harbor front, where even a comparatively slight recession would cause great damage to valuable property. The caving is, however, sometimes quite extensive, and in such cases great damage may be done. In October, 1891, the river front in the vicinity of French Market, covering an area some 200 feet in width and about 1,600 feet long, subsided from 5 to 10 feet, carrying with it the tracks of the Louisville and Nashville and Southern Pacific railways, the wharf, and several small buildings.

The work was begun in 1883 at the head of Carrollton Bend, where a mat 400 feet wide and 470 feet long was sunk, when high water and lack of material caused a suspension of operations.

Gouldsboro Bend.—In 1884 the work was taken up in Gouldsboro Bend. The caving had become active, and two spur dikes were put in

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normal to the general direction of the bank and another spur was about half finished. These spurs consist of a foundation mattress of willow and stone 200 feet wide and 350 long. On this foundation are placed six cribs, one above the other, constructed of poles filled in with brush and ballasted with stone. The bottom crib is 60 feet wide, and its upstream edge is placed 70 feet below the upper edge of the foundation mattress. The bottom crib is the shortest, and they increase in length so that the top crib, which is 22 feet wide, has a slope of about 3 horizontal to 1 vertical from the low-water line to deep water in the channel. The dikes extend out in the stream about 300 feet.

In 1886–87 two more spurs were put in place in Gouldsboro Bend. In the winter of 1887–88 the unfinished spur dike of the first season was completed, additions were made to one of the spurs of the previous season, and a new spur was built. This last spur was the largest one of the system, it being about 40 feet high, with the river end resting in 100 feet of water.

Greenville Bend.—Two spur dikes were constructed in Greenville Bend opposite Audubon Park in 1888–89. These spurs are 450 feet long and extend to a maximum depth of 150 feet. They are located about 1,000 feet apart. The upper spur was about 60 feet high and the lower spur about 48 feet high. They were built with a top slope of 1 on 3 from the low-water line to deep water.

Third district work.—Four spur dikes were built in 1889 in the third district of the city of New Orleans, extending from the foot of Emily street downstream. They were put in at intervals of about 1,000 feet. The river in this vicinity had encroached so far upon the city front that it became necessary to move the levee back so that it practically destroyed an improved street. It was therefore important to stop all further recession of the bank line. To this end the spurs in this locality were connected with the levee by a bank of earth extending from the end of the spur proper at the low-water line to the top of the levee. This embankment was paved with gravel and broken stone to protect it from scour. The subaqueous portions of the dikes were similar to those previously described.

In 1891 there were four dikes added in this district, the upper one being about opposite the foot of Clouet street.

In 1894–95 a continuous mattress 1,020 feet long and about 400 feet wide was laid between the two upper dikes in the third district to prevent erosion between the spurs. Mats were also placed immediately below four of the spurs for the same purpose.

Experience showed that the interval between the spurs was too great, and foundation mats for four intermediate spurs were laid in 1894–95. These spurs were completed in 1896–97, and four other intermediate spurs were also built and placed during the same season.

Carrollton Bend.—In 1890 work was resumed in Carrollton Bend along the Southport front and about 2,500 feet below the mattress that was sunk in 1883. Three sloping spurs were built in 1890–91, and during the following season two more spurs were put in.

In 1892–93 continuous revetment was put in between the spurs. During the past season a new mattress was placed near the lower end of Southport wharf, where a break in the bank had developed.

In 1897 serious caving at Algiers destroyed a large amount of valuable property. The ferry landing, ferry house, Grand Isle Railway depot, and some 400 feet of levee were destroyed. In order to prevent further disaster it was decided to extend the spur dikes from Gouldsboro down to Algiers Point.

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The project provided for the construction of eleven spur dikes spaced at intervals of 450 feet, the foundation mats to be 450 feet long by 150 feet wide. Short spurs without foundation mats were also to be put in between spurs, to act as buttresses in supporting the bank where it was unusually steep.

Work was begun on August 26, 1898, but was soon suspended on account of quarantine restrictions due to the prevalence of yellow fever. For two months during the best part of the season no work could be done. It was resumed on November 4 and continued until January 23, 1899, when operations were again suspended on account of high water. During this time six spur dikes and two buttresses were constructed. They extend from Slidell street down to Algiers Point, and cover that portion of the bank which was in greatest danger from erosion. As this work was done under great difficulties, mostly incident to quarantine regulations, the cost has been unusually high.

At the present time the banks of New Orleans Harbor are protected at the following points: In Carrollton Bend, 470 feet of mattress at the head of the bend and five spur dikes with continuous revetment between at Southport, covering about 2,500 feet of bank; two spur dikes 1,000 feet apart in Greenville Bend, opposite Audubon Park; six spur dikes in Gouldsboro Bend, covering about 4,000 feet of bank; six spur dikes and two buttresses above Algiers Point, covering about 2,500 feet of bank; and in the third district, below Clouet street, sixteen spur dikes with 1,020 feet of continuous revetment at the upper end, and additional mattresses placed on the lower side of the foundation mats of five spurs, all covering about 7,500 feet of bank. This gives a total of about 18,000 linear feet of bank that has been covered by dikes and revetment.

In the Third district a cave, extending from Bartholomew street downstream about 310 feet, occurred on August 23, 1898. The levee was carried down with it, as was also the skeleton wharf constructed by the Orleans Levee Board for the purpose of sustaining the levee.

The Orleans Levee Board are engaged in putting in a skeleton wharf all along the revetted front of the Third district. This wharf consists of nine rows of piling extending out into the river 100 feet or more. Along the shore side of the inner row of piling a line of sheet piling is placed, and against this the levee is built. This work threatens the destruction of the revetment already in place and effectually prevents the reenforcement and repair which is so essential to the proper maintenance of the dikes.

The conditions in Carrollton Bend, below Southport, are also threatening, and it is probable that an extension of the work will be required to hold the banks.

The work above Algiers Point to the Gouldsboro dikes will be continued and completed at an early day.

The valuable business property which lies along the water front of this great harbor is threatened with destruction by caving banks, which often develop with little or no warning. Under such unusual conditions it seems evident that ample funds should be provided to meet all emergencies and to carry the work to completion in such an economical and substantial manner as will give a fair degree of permanence to the banks.

For further information concerning the work in New Orleans Harbor, attention is invited to Appendix 4 transmitted herewith.

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PLANT.

The steamer *Mississippi*, which is used for the inspection trips of the commission and as a tender for the dredges, has been supplied with new boilers during the past year. Some of the bottom plates were damaged by striking hidden obstructions in the river, and the boat is now in the dry dock at Keokuk undergoing necessary repairs.

The plant pertaining to surveys, gauges, and observations has been cared for, and such minor repairs have been made as were found necessary to keep it in serviceable condition.

The plant in the First and Second districts has been cared for at Memphis when not in use. Much of it is in bad condition and will require extensive repairs and renewals. The steamer *Titan* was sunk on August 25 by striking a snag. The falling river left her on a dry bar, and she was not floated until December 29. She is now at St. Louis undergoing extensive repairs.

The steamer *Itasca* was also sunk, but was successfully raised and repaired. Minor repairs were made to all plant to keep it in serviceable condition.

In the Third district the plant when not in use was cared for at Greenville, Miss. The new steel-hull towboat *Arthur Hider* has been completed and is now in use. Minor repairs were made to the plant. Much of this plant is worn out and in bad condition, and extensive renewals are required. Twelve barges and two mat boats will be built this season.

The plant of the Fourth district has been cared for at New Orleans and Natchez when not employed on the various works. Much of the plant is in bad condition, and extensive repairs and renewals are required to meet the demands of the work. The steel-hull towboat *Genl. Newton* has been completed and delivered by the contractors. This boat takes the place of the *Osceola*, which was condemned and sold. Two barges were transferred to the Quartermaster's Department, and they are now being replaced with new ones.

The hull of the dredge *Ram* is in bad condition, and a contract has been entered into with the Springfield Boiler and Manufacturing Company for the construction of a steel hull to take the place of the present wooden hull.

Only such repairs as were absolutely needed to keep the plant in working condition were made during the year, on account of a lack of funds.

SURVEYS AND OBSERVATIONS IN THE DISTRICTS.

First and Second districts.—A survey was made in the upper St. Francis Levee district for a levee line from Birds Point to O'Briens, a distance of 12 miles. A survey of the Levee line of the White River Levee district, 74 miles in extent, was also made. Hydrographic surveys for the purpose of locating new works and ascertaining the condition of old works were made at Point Pleasant, Caruthersville, Island 34, Memphis Harbor, Nonconnah Rock, Helena Harbor, and at other points where work was in progress.

Third district.—Surveys were made to ascertain the rate of caving at Caulks Neck, Carters Neck, and in the following bends: Cypress, Choctaw, Rowdy, Spanish Moss, Walkers, Matthews, and Island 92. Complete surveys were also made to ascertain the condition of the several revetments.

Fourth district.—Surveys were made for a new line of levee in Kemps Bend, taking in the topography for some distance from the river. Sur-

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veys were also made of Giles Bend, Atchafalaya, and Old River from Simmesport to Red River Landing, and of the several caving bends in New Orleans Harbor.

LEVEES.

Since the last annual report of the commission two sundry civil bills have been passed by Congress containing appropriations for the improvement of the Mississippi River.

From the bill for the fiscal year ending June 30, 1899, approved July 1, 1899, the following allotments were made for levees:

Lower St. Francis district	$34,000	Lafourche district	$36,000
White River district	30,000	Barataria district	27,000
Upper Yazoo district	46,000	Pontchartrain district	76,000
Lower Yazoo district	350,000	Lake Borgne district	24,000
Upper Tensas district	215,000		
Lower Tensas district	150,000		1,075,000
Atchafalaya district	87,000		

From the bill for the fiscal year ending June 30, 1900, approved March 3, 1899, the following allotments were made for levees:

Upper St. Francis district	$20,000	Atchafalaya district	$98,800
Lower St. Francis district	123,500	Lafourche district	37,050
White River district	61,750	Barataria district	24,700
Upper Yazoo district	123,500	Pontchartrain district	74,100
Lower Yazoo district	247,000	Lake Borgne district	24,700
Upper Tensas district	197,600		
Lower Tensas district	217,300		1,250,000

During the past year 10,823,294 cubic yards of earthwork have been added to the levees, of which the United States built 7,686,758, and the State and local authorities 3,136,541 yards. Of the existing levees the State and local authorities have built, in the aggregate, about 60 per cent. The proportion in the several districts is very different, being greater where they have been long organized and prosperity and improvement have followed protection from overflow. It is not probable that the State and local contributions will be as great in the future as in the past, as their work has been done not only with the proceeds of special taxes, which will be continued, but also from the sale of bonds, to which, in many localities, a limit has been reached. In addition to the direct contributions mentioned the States and local authorities have invariably furnished the United States with the right of way for levees, paying all cost of expropriation, which, in many cases, has been a heavy burden.

The present condition of the levee system in the several basins and districts is as follows:

ST. FRANCIS BASIN.

The St. Francis Basin, on the right bank of the Mississippi, commences below Cape Girardeau and extends to the Helena Hills. Big Prairie Ridge, substantially above overflow, extending from the highlands at Commerce to New Madrid, divides the basin into the Upper and Lower St. Francis Levee district.

The Upper St. Francis Levee district, starting below Commerce, has a river front of 105 miles to New Madrid. It is subject to overflow only from this direction. Its area is about 700 square miles. The local authorities have built a levee from the hills at Commerce to the vicinity of Birds Point, at the confluence of the Ohio River, a distance of about 35 miles. Here the work enters the jurisdiction of the Mississippi River Commission. To complete the protection of the district requires

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a levee with a length of about 70 miles to near New Madrid, with contents of about 7,000,000 cubic yards of earthwork.

From the appropriation of 1899 an allotment of $20,000 was made for the commencement of this work.

The Lower St. Francis Levee district extends from the highlands below New Madrid, in the vicinity of Point Pleasant, to the Helena Hills. It has a river frontage of 218 miles and an area of about 3,500 square miles. Its overflow is mainly from the Mississippi front, but flood water can reach it through the gap between Cape Girardeau and Commerce, and also over low points in the Big Prairie Ridge when the upper district is overflowed. The former source of overflow has been cut off by a State levee, and the latter will be closed by the extension of levees from Birds Point to the vicinity of New Madrid.

This district is of recent organization. State work commenced there about 1892, and the first allotment made by the Mississippi River Commission was in 1894. The work now under construction extends from Point Pleasant to the bend back of Centennial Island, a distance of about 122½ miles. To this may be added a piece of levee, 6 miles long, in Walnut Bend, built by special appropriation in 1894 to prevent the confluence of the Mississippi and St. Francis rivers at that point. The 128½ miles of levee now under construction contain 7,409,908 cubic yards, and it is estimated that 5,667,190 more will be required to bring them to standard height and dimensions. The line is now continuous and of tolerably uniform but insufficient grade and section.

Both the States interested in this work—Missouri and Arkansas—but particularly the last named, have contributed largely to its construction. During the past year the Arkansas Levee district secured from its legislature the right to issue $750,000 bonds, the proceeds of which are to be applied to the extension of the levee system.

It is in contemplation by the United States and the local authorities to cooperate in the extension of levee protection to the lower end of the district, near the mouth of the St. Francis River, 9 miles above Helena, a distance of about 86½ miles. The estimated contents of this completion of the system are about 11,000,000 cubic yards.

WHITE RIVER BASIN.

This basin constitutes a single levee district, extending from the Helena hills nearly to the mouth of White River. It is overflowed mainly from the Mississippi front, but also by floods and back water in the White River. The upper end of the existing levee system is within the corporate limits of the city of Helena, and its lower end leaves the Mississippi and serves as a protection against overflow from the White River. The total length is about 79 miles, but the coöperation of the Government is confined to 64 miles, exclusive of the private levees mentioned. The basin has an area of about 910 square miles. The flood of 1897 found the levees of this district in incomplete condition, and several large breaks occurred. As these were in the front of the least improved part of the district, work has since been confined to the strengthening and enlargement of the remaining parts of the levee. The breaks are close together, and aggregate less than 2 miles in length. The existing contents of levees are 6,574,798 cubic yards, and 6,745,796 more are required to bring them to a standard grade and section.

This district, being relatively sparsely settled, and having been subject to uninterrupted overflow for many years, has contributed less than most others to the improvement of its levees. It is also true, from the

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small area of the reservoir and the return of overflow water at a short distance below its point of departure, that the diversion of flow here has less effect on the regimen of the river than is the case when crevasses occur in the larger and longer basins.

The basins and districts to be hereafter described have been thoroughly organized for a long time, and have all contributed largely to the improvement of their levees. These lines are now continuous, and have a tolerably uniform, but insufficient, grade and section.

YAZOO BASIN.

This basin, on the left bank of the river, extends from Memphis to Vicksburg, a distance of 370 miles. The leveed front is from the hills south of Horn Lake to near the mouth of the Yazoo River, which, with its tributaries, forms the drainage system of the entire basin. It is divided into two levee districts, the upper and lower. The division between these is arbitrary, founded on legislative enactment and not on any physical feature, like Prairie Ridge, separating the Upper and Lower St. Francis districts. Its overflows come exclusively from the Mississippi River.

The Upper Yazoo Levee district has levees beginning south of Horn Lake and extending to the southern line of Coahoma County, an unbroken length of 124 miles. These levees protect from overflow 3,281 square miles. The system has been in existence many years, and the expenditures of the local authorities have been large and constant. It now contains 15,781,281 cubic yards. It is estimated that 8,436,555 yards are still required to bring it to standard height and other dimensions.

The Lower Yazoo Levee district is continuous, except in administration, with the upper district. It has a levee line of about 186.6 miles, extending from the upper line of Bolivar County to near the mouth of Yazoo River, 12 miles above Vicksburg. Protected by this system is an area of 3,811 square miles. The present cubic contents are 26,601,026 yards. The additional yardage estimated for standard completion is 19,024,100. The local authorities, as well as those of the upper district, have been engaged for many years and spent large sums in the reclamation of this fertile region from overflow.

TENSAS BASIN.

This large domain is bounded on the north by the Arkansas, and from the mouth of that river extends down the right bank of the Mississippi to the Red River. It is therefore subject to overflow both from the Arkansas at its head and from the Mississippi along its front. It is drained by the Black and Ouachita, with numerous tributaries, into Red River, and thence down the Mississippi or Atchafalaya, according to the relative stages of these two rivers. For purposes of administration it is divided into an upper and lower levee district by an east and west line opposite Warrenton, about 10 miles below Vicksburg.

The Upper Tensas Levee district system is a continuation of the Arkansas State levees on the south bank of that river from Pine Bluff to Red Fork. Below this point the United States has now in course of construction a levee to and down the Mississippi nearly to the mouth of a local drain known as Cypress Creek. Instead of closing this an inner and overlapping line of levee has been built from the higher land about 7 miles back, at Amos Bayou Ridge, along the south bank of Cypress Creek to the main river at Lucca Landing, and thence down the front of the basin to the lower end of the district.

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The levees of this district are partly in Louisiana and partly in Arkansas. Both States, particularly the former, through their local organizations, have contributed freely to their construction. The State of Louisiana has spent large sums in its neighbor State for its own protection. The area protected by the system comprises about 2,200 square miles. In the levees already constructed there are 24,724,458 cubic yards, while 19,082,015 more are estimated as required in order to give them the standard grade and section.

The Lower Tensas Levee district extends in continuation of the upper from the latitude of Warrenton to the lower end of the basin. The line of levees is continuous to its present terminus at Bougeres Landing, about 26 miles above the mouth of the Red River. It protects an area of about 2,755 square miles, and in its present condition contains 15,365,509 cubic yards of embankment, while 13,604,000 more are required to bring it to the standard recommended by the commission.

The Kempe Levee is in this district. The continued caving of many years had forced the line of levees back to the edge of an impracticable swamp, cut up with sloughs and bayous. A small cave in the line during the past year was closed by a short but costly loop, but as a great part of the line was threatened, and several places were liable to break in the following year, it was evident that a new levee, or the protection of the caving bank by revetment, was absolutely necessary. Careful surveys made it apparent that a levee, running back to the better ground in the rear of the swamp, was of such magnitude that it could not be built in one year or with the resources then at the disposal of the commission for such purposes, but that a revetment about 3,000 feet long would cover those parts of the levee which were in immediate danger, and that such extensions as were proved necessary could be made in subsequent years. This course was therefore adopted.

ATCHAFALAYA BASIN.

This basin consists of a single levee district of the same name and extent. It has a front on the Mississippi River, with levees forming part of the general levee system under construction jointly by the United States and the State levee organizations. This frontage is 122 miles long.

The district has also lines of levee on the Atchafalaya, the Des Glaizes, and the Lafourche, aggregating 178 miles in length. These are exclusively constructed and maintained at the cost of the levee organization of the State of Louisiana. The district is therefore exposed to danger of overflow from three directions, but much more extensive disaster would result from a break on the Mississippi than from one on either of the above streams.

The area of land protected in this district is 6,195 square miles. The contents of the levees on the Mississippi in their present condition are 16,740,771 cubic yards, and 8,224,000 yards more are required to bring them to a safe standard.

LAFOURCHE BASIN.

This basin lies on the right bank of the river below the Atchafalaya, and in the angle formed by the Mississippi and the Bayou Lafourche. The high alluvial banks of this outlet form a natural division, as regards overflow, between it and the Atchafalaya. The area of the basin is 2,024 square miles; it is divided into two levee districts, the Lafourche and Barataria.

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The Lafourche Levee district extends along the right bank of the Mississippi from the head of the Lafourche to the corporate limits of the city of New Orleans. It cooperates with the General Government in the construction and maintenance of the levee system of the main river, 80 miles in length, and also has exclusive charge of the levees on the left bank of the Lafourche, 75 miles long, of equal importance for its protection from overflow. The existing Mississippi levees contain 7,004,126 cubic yards of embankment, and 3,920,000 more are considered necessary to bring them to a proper standard of security.

In 1886 the Government adopted a project for the improvement of Bayou Lafourche, which forms the boundary of the two districts, Atchafalaya and Lafourche, by the construction of locks at its head and dredging below. This would obviate the necessity of levees on the bayou. The appropriations made for this project have only been sufficient to do some of the necessary dredging without commencing the locks. The estimate for the entire work was $450,000. Since 1890 the two levee districts bordering on the bayou have spent over $1,100,000 on its levees. An effort is now being made by the State and local authorities of Louisiana to secure such appropriations from Congress as are needed for the completion of the project, in order that the large State expenditures on the bayou levees may be rendered unnecessary, and its resources applied exclusively to cooperation with the Government in completing the levees on the Mississippi River.

The Barataria Levee district extends along the right bank of the Mississippi from the lower limits of the city of New Orleans to the Head of the Passes, but its levee system terminates at the Jump with a length of about 71½ miles. The contents, as far as built, are 2,480,381 cubic yards, and it is estimated that 1,950,000 more are required for completion.

PONTCHARTRAIN BASIN.

This basin extends along the left bank of the river from the Baton Rouge hills to the Gulf. It has an area of 2,000 square miles and is divided into two levee districts, between which is the city of New Orleans. The upper district has the same name as the basin, and the lower is known as the Lake Borgne.

The Pontchartrain Levee district has a river frontage of about 130 miles and a continuous line of levee, containing, in its present condition, 12,473,692 cubic yards of earthwork. The estimate for standard completion includes 6,595,000 yards additional.

The Lake Borgne Levee district, below New Orleans, on the left bank, extends to the Head of the Passes. Its levee system, 70 miles long, stops at Fort St. Philip, and at present contains 2,834,743 cubic yards. It is estimated that 2,064,000 yards are required to bring it to the standard grade and section.

Additional information concerning the condition of the several levee districts and of the year's work will be found in the very full reports of Captains Newcomer and Winslow and Major Derby, district officers, which are attached as Appendixes 2, 3, and 4 to this report. The commission recognizes the energy and success of their administration, and also the very able assistance given to the commission by the engineer organizations of the several riparian States.

Accompaying the annual report of the commission for 1896, as Appendix 4, is a report of its committee on levees giving a preliminary estimate of the height on the different gauges which very high floods may be expected to reach when levees are made continuous, and of the

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additional quantity and cost of earthwork required to bring the levees, as then existing, to a grade 2 feet above this anticipated flood height. The amount of this estimated increase of contents was 121,991,044 cubic yards, and its cost, at an assumed rate of 15 cents per yard, was about $18,300,000. The great flood of 1897, immediately following the presentation of this project, flowed between levees which had been greatly extended and strengthened since any previous flood of equal magnitude and gave much information on the subject of future flood heights. While it made necessary some local changes in the details of the flood profile proposed in 1896, the general correctness of that estimate, both as regards grade and quantity, was sustained.

In 1898 the district officers were directed to go into this subject more thoroughly and to report their conclusions to the commission. The commission's estimate had been based only on the flood readings of the regular gauges, generally about 50 miles apart. It was assumed that this method would give a full average result, notwithstanding the many elevations and depressions which were known to exist above and below a uniform slope between the regular gauges, on account of the tortuous course of the river and the differences between river distances and levee lengths at the bends and points. These details were taken into consideration in the estimates and reports of the district officers with the results of a reduction of cubic contents of about 8,678,388 yards, but an advised increase of price from 15 to 18 cents per yard.

As these reports covered only the lines of levee then under construction, it is necessary, in order to make their conclusions comparable with the estimate of the commission, to add for the extension of the Lower St. Francis Levee throughout the district 11,000,000 and for the complete leveeing of the Upper St. Francis 7,000,000 cubic yards. Their aggregate estimate is, then, 113,312,656 cubic yards, at an average cost of 18 cents per cubic yard, or $20,396,278.08. These district reports accompany this annual report as appendixes, and to them is annexed Plate B, giving a profile of the flood heights from Cairo to Fort Jackson for 1897, 1898, and 1899, and the estimated future height of floods and levees.

The floods of the two years, 1898 and 1899, though less than that of 1897, still, on account of the improvement and extension of the levees, reached considerable heights in certain localities and give important information. It is interesting to trace their course. The flood of 1898 started at Cairo, with a gauge height 1.9 feet lower than the previous year. This difference was substantially maintained to New Madrid, from which point it steadily decreased to 0 below Plum Point, where the height of the two floods was about the same, and at Fulton 1898 exceeded the height of the 1897. This excess continued to Memphis, and was probably caused by the improvement and extension of the Lower St. Francis levees. Below Memphis the excess of 1897 was regained and increased to 2.6 at Helena, probably on account of the smaller volume of returned overflow water from St. Francis Basin at that point. From Helena to Arkansas City the readings of 1897 were from 1 to 2 feet higher than those of 1898, but from that point this difference decreased, until in the neighborhood of Lake Providence the gauge reading of 1898 was in excess of 1897 by 0.4. This may again be attributed to the more successful resistance presented by stronger levees in the later year. From Lake Providence down the gauge readings of 1898 steadily dropped below those of 1897, until there was a difference at Vicksburg of 3.1 feet and at the mouth of the Red River of 5.9 feet, attributable in large part to the absence of a return overflow wave from the Yazoo and Tensas basins. Below Red River the differ-

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ence, of course, steadily decreased until the river's slope reached Gulf level.

The flood of 1899 started from Cairo about 5.4 feet below that of 1897 and 3.5 feet below 1898. It was marked by an unusual continuance of the highest stage. Below Cairo to Memphis the slope of 1899 was substantially parallel to that of the previous year, the difference on the regular gauges being: Belmont, 2 feet, New Madrid, 2.3 feet; Cottonwood, 2 feet; Fulton, 2.5 feet; and Memphis, 2.3 feet. Between Memphis and Sunflower Landing the difference varied from 1 to 2.4 feet. Below this point the excess of height in the earlier year (1898) increased to 3 feet at White River, and continued substantially the same to Lake Providence. From here a slight but continuous reduction of difference prevailed as far as Red River Landing, where the gauge readings gave the height of 1890 water as 1 foot below that of 1898. This disappeared at and below Carrollton, where the high-water marks for the two years were about the same.

It is altogether probable that the experience of the future may make apparent the necessity of other changes in the proposed grade. The floods of 1898 and 1899 were uncomplicated by any large discharge from the St. Francis, White, or Arkansas rivers. Such a combination as occurred in 1897 might result, with improved levees, in greater flood heights between Memphis and Vicksburg than have been anticipated. It is not thought that provision for this contingency will require an amount of yardage more in excess of the net estimate given than will be covered by a contingency provision of 10 per cent., such as usually forms part of all engineering estimates.

In the meantime it is useful to have this standard of record, as a guide in the estimate for and distribution of work and in the allotment of funds for the building of levees on different parts of the river.

The Mississippi River Commission has recognized in the past the obligation of giving a substantially equal degree of security against overflow to each of the basins and districts, and the allotment of Government funds has been based on this intention, with such modifications as economic and financial conditions make advisable.

For instance, it is reasonable that a large basin with dense population and high cultivation should be kept in a position of greater security than one small and unimproved, because the damage, loss, and suffering from overflow to the regimen of the river, to property, and to persons would be very much greater in the former case.

Another consideration of weight in the allotment of funds is that whenever the levee system of any district has been brought to a condition which has afforded protection against overflow for a series of years, it is more important that this should be he held against a break than that progress should be hastened in districts in which this condition has not been reached. It is of the first importance that all which has been gained should be held. This is necessary, not only for reasons affecting the improvement of the river and the inhabitants of the more settled and improved districts, but also for the moral protection of the system from the outcry of failure, which arises from those who are ignorant of the conditions or out of sympathy with the improvement whenever a crevasse occurs. Explanation may be possible when the levees of a district are known to be incomplete or insufficient, but it is much more difficult when a disaster occurs in a district which has been considered as illustrating the efficiency of the levee system.

Again, there are many narrow basins of small area where the cost of levees would exceed the entire value of the land and improvements reclaimed, and others of so little length that the back water of floods,

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entering the outfall left for drainage at the lower end, would extend to and submerge all lands up to the head of the basin.

With the limitations imposed by such conditions, the commission have sought to make an equitable distribution of the funds intrusted to them, with the result which is showed in the following table. Such an apportionment has heretofore been difficult on account of the absence of information on which an estimate for the final completion of the system could be based, and which was only made accessible by the estimates and reports before mentioned.

This table also serves as an estimate for future levee work.

Name of district.	Length of levee line.	Area protected from overflow.	Contents of existing levees.	Additional yardage required.	Percentage completed.
	Miles.	*Sq. miles.*	*Cubic yds.*	*Cubic yds.*	
Upper St. Francis	70	700	.....	7,000,000	.....
Lower St. Francis	128.5	3,500	7,409,908	5,667,190	56.6
Extension Lower St. Francis	a 86.5			11,000,000	
White River	79	910	6,574,796	6,745,796	49.3
Upper Yazoo	124	3,281	15,761,281	8,436,555	65
Lower Yazoo	188.6	3,811	26,601,026	19,024,100	58.3
Upper Tensas	171.66	2,200	24,724,455	19,082,015	56.4
Lower Tensas	131.5	2,755	15,227,072	13,604,000	52
Atchafalaya	122	6,195	16,527,388	8,224,000	66.8
Lafourche	78	2,024	6,868,722	3,920,000	63.6
Barataria	71.5		2,456,027	1,950,000	55.8
Pontchartrain	123.5	2,000	12,443,772	6,595,000	65.3
Lake Borgne	70		2,834,743	2,064,000	57.9
	1,444.76	27,376	137,429,192	113,312,656	54.8
Contingencies, 10 per cent	.....	.....	.....	11,331,266	
				124,643,922	
Average cost per cubic yard.....cents	.....	.....	.....	$0.18	
				$22,435,905.96	

a Yet to be built.

The estimates which follow cover the amounts which, in the judgment of the Commission, can be advantageously expended during the fiscal year ending June 30, 1901. The method of continuing appropriations extending over a series of years, now twice adopted by Congress in appropriations for the improvement of the Mississippi River, has been found highly advantageous in the promotion of system, regularity, and economy in the work, and the Commission recommend a continuance of the same method.

Respectfully submitted.

G. L. GILLESPIE,
Colonel, Corps of Engineers, U. S. A.,
President Mississippi River Commission.
B. M. HARROD.
ROBERT S. TAYLOR.
AMOS STICKNEY,
Lieut. Col., Corps of Engineers, U. S. A.
THOS. H. HANDBURY,
Major, Corps of Engineers, U. S. A.
HENRY L. MARINDIN,
Assistant, United States Coast and Geodetic Survey.
J. A. OCKERSON.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

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Money statement.

Appropriations expended under Mississippi River Commission.

July 1, 1898, balance unexpended[1]		$1,984,705.37
Amount appropriated by sundry civil act of July 1, 1898	$1,983,333.00	
Amount appropriated by sundry civil act of March 3, 1899	2,583,333.00	
Amount appropriated by river and harbor act of March 3, 1899	185,000.00	
Amount received from Quartermaster's Department, U. S. Army, on account reimbursement for plant loaned during war of 1898 and lost at sea	8,000.00	
		4,759,666.00
		6,744,371.37
June 30, 1899, amount expended during fiscal year		2,363,871.75
July 1, 1899, balance unexpended		4,380,499.62
July 1, 1899, outstanding liabilities	$58,092.13	
July 1, 1899, amount covered by uncompleted contracts	747,656.07	
		805,748.20
July 1, 1899, balance available		3,574,751.42
Distributed as follows:		
Mississippi River Commission		46,491.16
Surveys, gauges, and observations		155,869.50
Levees		1,419,402.83
Revetment and contraction works, permanent channel improvements and protection		348,616.46
Dredges and dredging		682,725.38
Plant and miscellaneous		206,797.58
Improving harbors and tributaries		628,998.51
Works above Cairo		7,361.00
Reserve for allotment		78,489.00
		3,574,751.42

Amounts necessary to be appropriated for the fiscal year ending June 30, 1901.

For continuing improvement of Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission	$3,000,000.00
Protection of banks at or near Caruthersville, Mo	40,000.00
Improving harbor at Memphis, Tenn. (including Hopefield Bend)	50,000.00
Improving harbor at Helena, Ark	20,000.00
Improving harbor at Greenville, Miss	50,000.00
Protection of banks at Delta Point, Louisiana	50,000.00
Improving harbor at Natchez, Miss., and Vidalia, La	150,000.00
Improving harbor at New Orleans, La	300,000.00
Rectification Red and Atchafalaya rivers, Louisiana	100,000.00

[1] The unexpended balance, $1,984,693.52, shown in Annual Report for 1898, is increased by refundments during fiscal year of the following overpayments:

By Third district officer:	
April, 1899, allotment for Lower Yazoo Levee district	$7.36
July, 1898, allotment for Upper Tensas Levee district	.44
By Fourth district officer:	
August, 1898, allotment for Pontchartrain Levee district	4.05
	11.85

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899.

[Appropriation: Improving Mississippi River.]

SECRETARY MISSISSIPPI RIVER COMMISSION.

	Improving Mississippi River.					
	Mississippi River Commission.	Surveys, gauges, and observations.	Experimental dikes.	Dredges and dredging.	Patrol of the Mississippi river.	Total.
Amount expended on previous projects	$238,110.74	$855,247.37	.....	.....	.....	$1,093,358.11
Amount expended on present project to end of last fiscal year	265,780.76	565,516.97	.....	a800,281.64	$1,055.56	1,632,634.93
Balance unexpended at end of last fiscal year	17,219.24	14,918.36	.....	609,612.66	.....	701,750.26
Amount appropriated or allotted since (net)	75,000.00	185,000.00	$66,071.02	716,800.00	.....	1,042,871.02
	92,219.24	199,918.36	66,071.02	1,386,412.66	.....	1,744,621.28
Amount expended from beginning of present fiscal year to end of previous month	40,396.24	50,073.14	(b)	329,394.95	.....	419,864.33
Amount expended during the month	2,806.56	4,388.58	216.45	c 52,389.70	.....	59,801.29
	43,202.80	54,461.72	216.45	381,784.65	.....	479,665.62
Balance unexpended at end of month	49,016.44	145,456.64	65,854.57	1,004,628.01	.....	1,264,955.66
In Treasury United States	40,297.91	133,458.16	52,000.00	921,973.61	.....	1,147,729.68
In hand	8,718.53	11,998.48	13,854.57	82,654.40	.....	117,225.98
	49,016.44	145,456.64	65,854.57	1,004,628.01	.....	1,264,955.66
Outstanding liabilities at end of month	2,525.28	4,587.90	8,028.16	23,115.08	.....	38,256.42
Amount covered by existing contracts at end of month	.....	.....	.....	298,787.55	.....	298,787.55
	2,525.28	4,587.90	8,028.16	321,902.63	.....	337,043.97
Balance available at end of month	46,491.16	140,868.74	57,826.41	682,725.38	.....	927,911.69

a Does not include $388,097.12 expended by officer in charge of first and second districts, and $2,506.99 expended by officer in charge of fourth district.
b $8,928.98 expended by officer in charge of first and second districts.
c Includes $8.49 in Treasury Settlement No. 7,303 of June 24, 1899, with Missouri Pacific Railway Company, for passenger transportation.

WORKS ABOVE CAIRO.

	Protection near Cairo.a	Des Moines Rapids to Ohio River.	Total.
Amount expended on previous projects	.....	.....	.....
Amount expended on present project to end of last fiscal year	$41,400.00	$687,632.53	$729,032.53
Balance unexpended at end of last fiscal year	8,600.00	.....	8,600.00
Amount appropriated or allotted since (net)	.....	.....	.....
	8,600.00	.....	8,600.00
Amount expended from beginning of present fiscal year to end of previous month	1,200.00	.....	1,200.00
Amount expended during the month	.....	.....	.....
	1,200.00	.....	1,200.00
Balance unexpended at end of month	7,400.00	.....	7,400.00
In Treasury United States	7,400.00	.....	7,400.00
In hand	.....	.....	.....
	7,400.00	.....	7,400.00
Outstanding liabilities at end of month	39.00	.....	39.00
Amount covered by existing contracts at end of month	.....	.....	.....
	39.00	.....	39.00
Balance available at end of month	7,361.00	.....	7,361.00

a Includes only work under act of July 5, 1884.

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Consolidated statement of condition of appropriations and allotments under Mississippi Rirer Commission on June 30, 1899—Continued.

FIRST AND SECOND DISTRICTS.

[Appropriations: Improving Mississippi River; improving barbor at Memphis, Tenn.]

	Improving Mississippi River.				
	Surveys, gauges, and observations.	Upper St. Francis Levee district.	Lower St. Francis Levee district.	White River Levee district.	Upper Yazoo Levee district.
Amount expended on previous projects					
Amount expended on present project to end of last fiscal year	$93,497.69		$430,926.10	$1,028,243.89	$876,909.64
Balance unexpended at end of last fiscal year	675.42		4,700.90	15,740.71	32,442.14
Amount appropriated or allotted since (net)	5,000.00	$20,000.00	157,500.00	91,750.00	169,500.00
	5,675.42	20,000.00	162,200.90	107,490.71	201,942.14
Amount expended from beginning of present fiscal year to end of previous month	674.66		27,743.02	41,859.24	77,589.29
Amount expended during the month			4,805.43	1,425.38	841.15
	674.66		32,548.45	43,284.62	78,430.44
Balance unexpended at end of month	5,000.76	20,000.00	129,652.45	64,206.09	123,511.70
In Treasury United States	3,000.00	15,000.00	117,500.00	51,750.00	113,500.00
In hand	2,000.76	5,000.00	12,152.45	12,456.09	10,011.70
	5,000.76	20,000.00	129,652.45	64,206.09	123,511.70
Outstanding liabilities at end of month			500.00	500.00	3,000.00
Amount covered by existing contracts at end of month			980.00	3,707.18	
			1,480.00	4,207.18	3,000.00
Balance available at end of month	5,000.76	20,000.00	128,172.45	59,998.91	120,511.70

	Improving Mississippi River.				
	Walnut Bend Levee (preservation of works at).	Preservation of works.	Plum Point Reach.	Experimental dikes.	Removal Nonconnah Rock.
Amount expended on previous projects					
Amount expended on present project to end of last fiscal year	$16,681.31	$54,846.92	$4,868,660.62		$6,000.00
Balance unexpended at end of last fiscal year	13,318.69	20.97			
Amount appropriated or allotted since (net)			100,000.00	$8,928.98	3,000.00
	13,318.69	20.97	100,000.00	8,928.98	3,000.00
Amount expended from beginning of present fiscal year to end of previous mouth	11,462.10	20.97	21,251.70	8,928.98	3,000.00
Amount expended during the month			625.00		
	11,462.10	20.97	21,876.70	8,928.98	3,000.00
Balance unexpended at end of month	1,856.59		78,123.30		
In Treasury United States			65,000.00		
In hand	1,856.59		13,123.30		
	1,856.59		78,123.30		
Outstanding liabilities at end of month					
Amount covered by existing contracts at end of month					
Balance available at end of month	1,856.59		78,123.30		

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899—Continued.

FIRST AND SECOND DISTRICTS—Continued.

	Improving Mississippi River.				
	Plant.	Hickman, Ky.	At New Madrid, Mo.	Caruthersville, Mo.	Preservation of works at Hopefield Bend.
Amount expended on previous projects	.....	.....	.....	.....	.....
Amount expended on present project to end of last fiscal year	$709,841.97	$89,182.00	$60,827.02	.....	$13,354.27
Balance unexpended at end of last fiscal year	10,858.01	.....	1,172.98	.....	6,645.73
Amount appropriated or allotted since (net)	40,000.00	a 6,000.00	90,000.00	$55,000.00	60,000.00
	50,858.01	6,000.00	91,172.98	55,000.00	66,645.73
Amount expended from beginning of present fiscal year to end of previous month	16,767.79	.....	50,734.23	17,490.04	5,241.45
Amount expended during the month	6,255.20	.....	.....	.....	.....
	23,022.90	.....	50,734.23	17,490.04	5,241.45
Balance unexpended at end of month	27,835.11	6,000.00	40,438.75	37,509.96	61,404.28
In Treasury United States	15,471.33	6,000.00	30,000.00	35,000.00	59,000.00
In hand	12,363.78	.....	10,438.75	2,509.96	2,404.28
	27,835.11	6,000.00	40,438.75	37,509.96	61,404.28
Outstanding liabilities at end of month	6,000.00	.....	.....	.....	.....
Amount covered by existing contracts at end of month	2,180.55	.....	.....	.....	.....
	8,180.55	.....	.....	.....	.....
Balance available at end of month	19,654.56	6,000.00	40,438.75	37,509.96	61,404.28

	Improving Mississippi River.			
	Memphis, Tenn.	At Helena, Ark.	Expended allotments.	Total.
Amount expended on previous projects	.....	.....	.....	.....
Amount expended on present project to end of last fiscal year	.....	$130,471.63	b $506,847.12	$8,886,240.18
Balance unexpended at end of last fiscal year	.....	10,028.37	.....	95,603.92
Amount appropriated or allotted since (net)	45,000.00	60,000.00	.....	911,678.98
	45,000.00	70,028.37	.....	1,007,282.90
Amount expended from beginning of present fiscal year to end of present month	31,795.74	40,006.21	.....	354,565.33
Amount expended during the month	529.11	.....	.....	14,481.27
	32,324.85	40,006.21	.....	369,046.60
Balance unexpended at end of month	12,675.15	30,022.16	.....	638,236.30
In Treasury United States	5,000.00	20,000.00	.....	536,221.33
In hand	7,675.15	10,022.16	.....	102,014.97
	12,675.15	30,022.16	.....	638,236.30
Outstanding liabilities at end of month	.....	.....	.....	10,000.00
Amount covered by existing contracts at end of month	.....	.....	.....	6,867.73
	.....	.....	.....	16,867.73
Balance available at end of month	12,675.15	30,022.16	.....	621,368.57

a Allotment from appropriation by sundry civil act of March 3, 1899, by resolution of Mississippi River Commission, June 20, 1899 (Proc., p. 560), approved by Secretary of War July 6, 1899.
b Columbus, Ky., $43,750; improving St. Francis River, $75,000; dredges and dredging, $388,097.12.

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899—Continued.

FIRST AND SECOND DISTRICTS—Continued.

	Improving harbor at Memphis, Tenn.			Grand total.
	Improving harbor at Memphis, Tenn.	Improving harbor at Memphis, Tenn. (Wolf River).	Total.	
Amount expended on previous projects				
Amount expended on present project to end of last fiscal year	$1,422,377.38	$14,275.62	$1,436,653.00	$10,322,893.18
Balance unexpended at end of last fiscal year	2,661.39	30,724.38	33,385.77	128,989.69
Amount appropriated or allotted since (net)				911,678.98
	2,661.39	30,724.38	33,385.77	1,040,668.67
Amount expended from beginning of present fiscal year to end of previous month	2,661.39	10,354.30	13,015.69	367,581.02
Amount expended during the month		440.11	440.11	14,921.38
	2,661.39	10,794.41	13,455.80	382,502.40
Balance unexpended at end of month		19,929.97	19,929.97	658,166.27
In Treasury United States		13,000.00	13,000.00	549,221.33
In hand		6,929.97	6,929.97	108,944.94
		19,929.97	19,929.97	658,166.27
Outstanding liabilities at end of month		600.00	600.00	10,600.00
Amount covered by existing contracts at end of month				6,867.73
		600.00	600.00	17,467.73
Balance available at end of month		19,329.97	19,329.97	640,698.54

THIRD DISTRICT.

[Appropriations: Improving Mississippi River; improving harbor at Vicksburg, Miss.]

	Improving Mississippi River.				
	Surveys, gauges, and observations.	Lower Yazoo Levee district.	Upper Tensas Levee district.	Ashbrook Neck.	Greenville, Miss.
Amount expended on previous projects					
Amount expended on present project to end of last fiscal year	$72,680.91	$2,066,129.01	$3,403,627.35	$442,271.26	$698,677.45
Balance unexpended at end of last fiscal year	248.41	142,113.38	179,430.45	7,677.05	1,965.57
Amount appropriated or allotted since (net)	*5,000.00	*604,000.00	*412,600.00	*20,000.00	*176,000.00
	5,248.41	746,113.38	592,030.45	27,677.05	177,965.57
Amount expended from beginning of present fiscal year to end of previous month	248.41	378,922.98	243,335.52	5,933.64	101,008.84
Amount expended during the month		12,470.19	9,049.47	1,064.50	526.14
	248.41	391,393.17	252,934.99	6,998.14	101,534.98
Balance unexpended at end of month	5,000.00	354,720.21	339,095.46	20,678.91	76,430.59
In Treasury United States	5,000.00	347,300.00	332,600.00	20,000.00	76,000.00
In hand		7,420.21	6,495.46	678.91	430.59
	5,000.00	354,720.21	339,095.46	20,678.91	76,430.59
Outstanding liabilities at end of month		1,500.00	1,500.00	678.91	430.59
Amount covered by existing contracts at end of month		106,220.21	139,995.46		
		107,720.21	141,495.46	678.91	430.59
Balance available at end of month	5,000.00	247,000.00	197,600.00	20,000.00	76,000.00

*See notes *b*, *c*, *d*, *e*, and *f* at bottom of page 3332.

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899—Continued.

THIRD DISTRICT—Continued.

	Improving Mississippi River.					
	Lake Providence Reach.	Delta Point, La.	Stone.	Plant.	Expended allotments.	Total.
Amount expended on previous projects						
Amount expended on present project to end of last fiscal year	$3,534,679.06	$143,510.49	$180,912.82	$619,682.96	*a* $588,082.81	$11,750,254.12
Balance unexpended at end of last fiscal year	4,394.24	2,745.72	9,087.18	48,978.75		396,640.75
Amount appropriated or allotted since (net)	*g* 70,000.00	40,000.00		*h* 80,000.00		1,407,600.00
	74,394.24	42,745.72	9,087.18	128,978.75		1,804,240.75
Amount expended from beginning of present fiscal year to end of previous month	13,426.08	2,083.21	8,809.94	65,506.54		819,825.16
Amount expended during the month	75.00		277.24	2,376.74		25,839.28
	13,501.08	2,083.21	9,087.18	67,883.28		845,664.44
Balance expended at end of month	60,893.16	40,662.51		61,095.47		958,576.31
In Treasury United States	60,000.00	25,000.00		60,000.00		925,900.00
In hand	893.16	15,662.51		1,095.47		32,676.31
	60,893.16	40,662.51		61,095.47		958,576.31
Outstanding liabilities at end of month	400.00	500.00		1,095.47		6,104.97
Amount covered by existing contracts at end of month						246,215.67
	400.00	500.00		1,095.47		252,320.64
Balance available at end of month	60,493.16	40,162.51		60,000.00		706,255.67

NOTES.—Under amounts appropriated or allotted are included the following sums:

Allotments from appropriation by sundry civil act approved Mar. 3, 1899, by resolutions Mississippi River Commission Mar. 9, 1899 (Proc., pp. 547, 548, 549, 551), approved by Secretary of War, Mar. 13, 1899—

a Lake Bolivar front, $145,358.04; improving harbor at Vicksburg, Miss., $442,724.77.
b Surveys, gauges, and observations $5,000.00
c Lower Yazoo Levee district 247,000.00
d Upper Tensas Levee district 197,600.00
e Ashbrook Neck 20,000.00
g Lake Providence Reach 25,000.00
h Plant 60,000.00
554,600.00

Appropriation by sundry civil act approved Mar. 3, 1899 (Proc., p. 547)—
f Greenville, Miss. (rectifying the bank at) 50,000.00

Allotment from appropriation by sundry civil act approved Mar. 3, 1899, by resolution Mississippi River Commission Apr. 30, 1899 (Proc., p. 564), approved by Secretary of War May 27, 1899—
g Lake Providence Reach 25,000.00

Allotment from appropriation by sundry civil act approved Mar. 3, 1899, by resolution Mississippi River Commission June 20, 1899 (Proc., p. 581), approved by Secretary of War July 6, 1899—
f Greenville Harbor, Miss 26,000.00
$655,600.00

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899—Continued.

FOURTH DISTRICT.

[Appropriations: Improving Mississippi River; improving harbor at Natchez, Miss., and Vidalia, La.; improving harbor at New Orleans, La.; improving Atchafalaya and Red rivers, La.]

	Improving Mississippi River.			
	Surveys, gauges, and observations.	Lower Tensas Levee district.	Atchafalaya Levee district.	Lafourche Levee district.
Amount expended on previous projects	.....	.....	.....	.....
Amount expended on present project to end of last fiscal year	$77,177.52	$1,838,067.03	$1,076,474.34	$411,353.87
Balance unexpended at end of last fiscal year	2,959.62	134,681.91	107,835.32	44,080.05
Amount appropriated or allotted since (net)	*c* 5,000.00	*d* 375,300.00	*e* 185,800.00	*f* 73,050.00
	7,959.62	509,981.91	293,635.32	117,130.05
Amount expended from beginning of present fiscal year to end of previous month	2,959.62	*p* 226,245.85	118,204.34	28,776.05
Amount expended during the month	.....	6,717.15	394.26	.....
	2,959.62	232,963.00	118,598.60	28,776.05
Balance unexpended at end of month	5,000.00	277,018.91	175,036.72	88,354.00
In Treasury United States	5,000.00	257,300.00	148,800.00	62,050.00
In hand	.....	19,718.91	26,236.72	26,304.00
	5,000.00	277,018.91	175,036.72	88,354.00
Outstanding liabilities at end of month	.....	294.24	352.37	34.33
Amount covered by existing contracts at end of month	.....	44,345.94	21,868.87	38,284.46
	.....	44,640.18	22,221.24	38,318.79
Balance available at end of month	5,000.00	232,378.73	152,815.48	50,035.21

	Improving Mississippi River.			
	Barataria Levee district.	Pontchartrain Levee district.	Lake Borgne Levee district.	Plant.
Amount expended on previous projects	.....	.....	.....	.....
Amount expended on present project to end of last fiscal year	$247,833.34	$849,480.21	$209,630.07	$11,808.12
Balance unexpended at end of last fiscal year	21,199.53	73,254.27	22,365.06	18,191.88
Amount appropriated or allotted since (net)	*g* 51,700.00	*h* 10,100.00	*i* 48,700.00	*j* 78,000.00
	72,899.53	223,354.27	71,065.06	96,191.88
Amount expended from beginning of present fiscal year to end of previous month	15,046.55	*q* 63,258.52	25,444.33	15,224.26
Amount expended during the month	67.94	119.81	93.39	2,854.89
	15,114.49	63,378.33	25,537.72	18,079.15
Balance unexpended at end of month	57,785.04	159,975.94	45,527.34	78,112.73
In Treasury of United States	39,700.00	134,100.00	29,700.00	64,444.00
In hand	18,085.04	25,875.94	15,827.34	13,668.73
	57,785.04	159,975.94	45,527.34	78,112.73
Outstanding liabilities at end of month	125.80	524.00	12.64	512.62
Amount covered by existing contracts at end of month	21,856.81	16,646.43	15,088.88	8,283.50
	21,982.61	17,170.43	15,101.52	8,796.12
Balance available at end of month	35,802.43	142,805.51	30,425.82	69,316.61

For foot notes *c*, *d*, *e*, *f*, *p*, *g*, *h*, *i*, *j*, and *q* see bottom of page 3335.

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Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1899—Continued.

FOURTH DISTRICT—Continued.

	Improving Mississippi River.				
	Giles Bend.	Bondurant.	Kempe Bend.	Expended allotments.	Total.
Amount expended on previous projects					
Amount expended on present project to end of last fiscal year				*a* $136,506.99	$4,858,331.49
Balance unexpended at end of last fiscal year	$110,000.00				584,567.64
Amount appropriated or allotted since (net)		*k* $10,000.00	*l* $180,000.00		1,157,650.00
	110,000.00	10,000.00	180,000.00		1,692,217.64
Amount expended from beginning of present fiscal year to end of previous month	29,898.61				525,058.13
Amount expended during the month	6,828.17				17,075.61
	36,726.78				542,133.74
Balance unexpended at end of month	73,273.22	10,000.00	180,000.00		1,150,083.90
In Treasury United States	60,000.00	10,000.00	180,000.00		991,094.00
In hand	13,273.22				158,989.90
	73,273.22	10,000.00	180,000.00		1,150,083.90
Outstanding liabilities at end of month	1,122.37				2,978.37
Amount covered by existing contracts at end of month	5,410.23				171,785.12
	6,532.60				174,763.49
Balance available at end of month	66,740.62	10,000.00	180,000.00		975,320.41

	Improving harbor of Natchez, Miss., and Vidalia, La.	Improving harbor of New Orleans, La.	Improving Atchafalaya and Red rivers, Louisiana.	Grand total.
Amount expended on previous projects				
Amount expended on present project to end of last fiscal year	$210,307.74	$787,138.00	$309,371.53	$6,765,148.76
Balance unexpended at end of last fiscal year	*b* 21,944.30	101,251.86	67,337.87	725,101.67
Amount appropriated or allotted since (net)	*m* 50,000.00	*n* 110,000.00	*o* 25,000.00	1,342,650.00
	71,944.30	211,251.86	92,337.87	2,067,751.67
Amount expended from beginning of present fiscal year to end of previous month	21,944.30	*r* 75,099.51	14,756.64	636,858.58
Amount expended during the month		636.72	268.38	17,980.71
	21,944.30	75,736.23	15,025.92	654,839.29
Balance unexpended at end of month	50,000.00	135,515.63	77,312.85	1,412,912.38
In Treasury United States	50,000.00	125,169.63	55,000.00	1,221,094.00
In hand		10,515.63	22,312.85	191,818.38
	50,000.00	135,515.63	77,312.85	1,412,912.38
Outstanding liabilities at end of month		47.50	65.87	3,091.74
Amount covered by existing contracts at end of month		5,000.00	19,000.00	195,785.12
		5,047.50	19,065.87	198,876.86
Balance available at end of month	50,000.00	130,468.13	58,246.98	1,214,035.52

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Consolidated statement of all appropriations expended under the Mississippi River Commission to June 30, 1899.

Act of June 28, 1879 (organic)		$175,000.00
Act of June 16, 1880 (sundry civil)		150,000.00
Act of March 3, 1881 (river and harbor)		1,000,000.00
Act of March 3, 1881 (sundry civil)		150,000.00
Act of August 2, 1882 (river and harbor)		4,123,000.00
Act of August 7, 1882 (sundry civil)		150,000.00
Act of March 3, 1883 (sundry civil)		150,000.00
Act of January 19, 1884 (river and harbor)		1,000,000.00
Act of July 5, 1884 (river and harbor)		75,000.00
Act of July 5, 1884 (river and harbor), less $5,000 transferred to snag-boat service		2,065,000.00
Act of July 7, 1884 (sundry civil)		75,000.00
Act of August 5, 1886 (river and harbor), less $5,942.60 for expenses office Chief of Engineers		1,994,057.40
Act of August 5, 1886 (river and harbor), less $47.30 for expenses office Chief of Engineers		29,952.70
Act of August 11, 1888 (river and harbor), less $4,859 for expenses office Chief of Engineers		2,840,141.00
Act of August 11, 1888 (river and harbor)		75,000.00
Act of October 2, 1888 (sundry civil)		35,000.00
Act of October 19, 1888 (deficiency), less $4,214.39 reverted to the Treasury		20,785.61
Act of September 19, 1890 (river and harbor)		3,200,000.00
Act of September 30, 1890 (deficiency)		5,625.00
Act of March 3, 1891 (deficiency)		1,950.00
Act of March 3, 1891 (joint resolution)		1,000,000.00
Act of July 13, 1892 (river and harbor)		2,470,000.00
Act of July 28, 1892 (deficiency)		44.80
Act of March 3, 1893 (sundry civil)		2,665,000.00
Act of August 18, 1894 (river and harbor)		485,000.00
Act of August 18, 1894 (sundry civil)		2,665,000.09
Act of March 2, 1895 (sundry civil)		2,665,000.00
Act of June 3, 1896 (river and harbor)		909,000.00
Joint resolution approved March 31, 1897 (Public, No. 6)		250,000.00
Act of June 4, 1897 (sundry civil)		2,933,333.00
Act of July 19, 1897 (deficiency)		625,000.00
Act of July 1, 1898 (sundry civil)		1,983,333.00
Act of March 3, 1899 (sundry civil)		2,583,333.00
Act of March 3, 1899 (river and harbor)		185,000.00
Total specific appropriations		38,734,555.51
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $128.42 reverted to Treasury	$272,504.96	
Same for works above Cairo, under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Amount received from Quartermaster's Department, U. S. Army, on account reimbursement for plant loaned during war of 1898 and lost at sea		8,000.00
Total		39,037,693.00

a Dredges and dredging, $2,506.99; preservation of works, $134,000.

b Amount reported June 30, 1898, $131,944.30, included $110,000 allotment from appropriation for improving Mississippi River for prevention of cut-off at Giles Bend, Louisiana, which amount is now carried under allotment for Giles Bend.

NOTES.—Under amounts appropriated or allotted are included the following sums:

Allotments from appropriation by sundry civil act approved March 3, 1899, by resolution Mississippi River Commission Mar. 9, 1899 (Proc., pp. 547, 548, 549, 551), approved by Secretary of War Mar. 13, 1899—

c Surveys, gauges, and observations	$5,000	
d Lower Tensas Levee district	217,300	
e Atchafalaya Levee district	98,800	
f Lafourche Levee district	87,050	
g Barataria Levee district	24,700	
h Pontchartrain Levee district	74,100	
i Lake Borgne Levee district	24,700	
j Plant	64,444	
l Kempe Bend	180,000	
		$726,094

Allotment from appropriation by sundry civil act approved March 3, 1899, by resolution Mississippi River Commission June 21, 1899 (Proc., p. 582), approved by Secretary of War July 6, 1899—

k Bondurant		10,000

Appropriations by river and harbor act approved March 3, 1899 (Proc., p. 549)—

m Improving harbor at Natches, Miss., and Vidalia, La	$50,000	
n Improving harbor at New Orleans, La	110,000	
o Improving Atchafalaya and Red rivers, Louisiana	25,000	
	185,000	
		$921,094

p Amount formerly reported reduced $169.63, error in amount expended during month of January, 1899.

q Amount formerly reported reduced $4.05, error in amount expended during month of October, 1898.

r Amount formerly reported increased $169.63, error in amount expended during month of January, 1899.

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Consolidated statement of all appropriations expended under the Mississippi River Commission to June 30, 1899—Continued.

EXPENDED.

Location and object.	To June 30, 1898.	During year ending June 30, 1899.	Total.
Mississippi River Commission	$503,891.50	$43,202.80	$547,094.30
Surveys, gauges, and observations	1,664,120.46	58,344.41	1,722,464.87
Levees	a12,607,244.19	1,294,442.93	13,901,687.12
Revetment and contraction works, permanent channel improvements and protection	9,214,840.69	54,463.10	9,269,303.79
Dredges and dredging	1,190,885.75	381,784.65	1,572,670.40
Plant and miscellaneous	1,342,388.61	118,130.76	1,460,519.37
Improving harbors and tributaries	5,040,917.90	412,303.10	5,453,221.00
Works above Cairo	729,032.53	1,200.00	730,232.53
Total expended	32,298,321.63	2,368,871.75	34,657,193.38
Balance unexpended June 30, 1899			4,302,010.62
Reserve for allotment			78,489.00
Total appropriated			39,037,693.00

a The amount, $12,607,256.04, reported in annual report for 1898, is reduced by refundments during fiscal year of the following overpayments:

By Third District officer, April, 1899 allotment for Lower Yazoo Levee district	$7.36
By Third District officer, July, 1899, allotment for Upper Tensas Levee district	.44
By Fourth District officer, August, 1898, allotment for Pontchartrain Levee district	4.05
	11.85

LIST OF APPENDIXES ACCOMPANYING THE ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1899.

Appendix 1.

Report of Capt. Mason M. Patrick, secretary of the commission, on work done in the office of the commission, on surveys, gauges, and observations, and on dredges and dredging. (42 plates.)

Money statement.
Abstract of proposals.
List of contracts in force.
Statement of charts issued and sold.
List of civilian engineers.
Approximate value of plant.
List of appendixes accompanying the report.
List of plates accompanying the report.

1 A.—Laws affecting the Mississippi River Commission, July 1, 1898, to June 30, 1899.

1 B.—Specifications for the construction of dredge *Iota*.

1 C.—Report of Assistant Engineer A. T. Morrow on triangulation work between St. Paul and Aitkin, Minn., and on changes in the elevations of the bed of the river below Baton Rouge, La.

1 D.—Report of Surveyor W. S. Williams on precise level work between St. Paul and Aitkin, Minn.

1 E.—Instructions for precise level work amended to date.

1 F.—Report of Assistant Engineer Kivas Tully on gauges, reduction of physical data, mean Gulf level, and office publications.

1 G.—Report of Assistant Engineer Thomas Middleton on construction and repairs of dredging plant.

1 H.—Report of Assistant Engineer F. B. Maltby on dredging operations during the low-water season of 1898, on capacity tests of dredges, and on care and repair of dredging plant.

Appendix 2.

Report of Capt. E. Eveleth Winslow upon operations in the First and Second districts. (13 plates.)

Money statement.
Report of Assistant Engineer Aug. J. Nolty on work done at New Madrid, Caruthersville, Plum Point Reach, experimental dikes at Point Pleasant.
Report of Assistant Engineer W. M. Rees on work done at Hopefield Bend, Memphis, Helena, and Wolf River.
Report of Assistant Engineer Charles Le Vasseur on the work of removing Nonconnah rock.
Report of Assistant Engineer Aug. J. Nolty on care and repair of plant.
Abstract of proposals.
List of civilian engineers.

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Appendix 3.

Report of Capt. H. C. Newcomer upon operations in the Third District (2 plates).
Money statement.
Abstract of proposals.
List of civilian engineers.
Statement of contracts in force.
Report of Asst. Engineer Arthur Hider on surveys, revetment work, stone supply, and the care and repair of plant.
Report of Asst. Engineer H. St. L. Coppée on construction, care, and repair of levees in the Lower Yazoo Levee District, with an account of caving banks in the district, levee construction by machinery, new levees that will probably be required, description of high water, seepage observations, tables showing rainfall and levee work done in Lower Yazoo Levee District.
Report of Asst. Engineer E. C. Tollinger on levee work in the Upper Tensas District, with a description of the Red Fork and Cypress Creek levees, observations on seepage, flooded area, sand boils, drainage, caving banks, banquettes, proposed new levee line from Old River to Lake Providence, tables showing levee work done, and estimates of amount of work required and cost to complete levee line to Commission grade.
Tables showing cost of work done by the United States on levees.

Appendix 4.

Report of Maj. George McC. Derby on operations in the Fourth District, with tables relating to amount and cost of levees (6 plates).
Money statement.
4 A.—Approximate value of plant.
4 B.—Commercial statistics.
4 C.—List of civilian engineers.
4 D.—Report of Asst. Engineer H. S. Douglas on work in Giles Bend (Natchez and Vidalia harbors), with details as to cost of work and delays due to quarantine regulations.
4 E.—Report of Asst. Engineer H. S. Douglas on work at Algiers Point and Southport (New Orleans Harbor), with an account of experiments in towing mattress from the willow bars to the works, details of cost of work, caving in the Third District, and work of Orleans Levee Board.
4 F.—Report of Asst. Engineer H. S. Douglas on care and repair of plant.
4 G.—Report of Asst. Engineer A. F. Woolley, jr., on work done at the junction of the Red and Atchafalaya rivers, with an account of dredging operations in Old River, description of sill dams in Atchafalaya River, changes in cross section in Old River, and recession of bank at mouth of Old River; also survey of New Orleans Harbor, speed trials of the new towboat *Gen. John Newton*, and experiments made to obtain a substitute for rock to be used in revetment work.
4 H.—Report of Asst. Engineer W. J. Hardee on levee work in the Fourth District, including tabulated statement for each levee district, levee construction by means of dredges, muck ditches, conditions at Kempe Bend, and difficulties encountered in building the new Kempe loop.
4 I.—Abstracts of proposals.
4 J.—Statement of contracts in force.

APPENDIX 1.

REPORT OF CAPT. MASON M. PATRICK, CORPS OF ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

MISSISSIPPI RIVER COMMISSION, OFFICE OF THE SECRETARY,
St. Louis, Mo., May 31, 1899.

COLONEL: I have the honor to submit the following annual report for the year ending May 31, 1899.

This office was in charge of Capt. H. E. Waterman, Corps of Engineers, until October 26, 1898, the date of his death; all work prior to that date was done by his direction.

I assumed charge on October 29, 1898.

The work under the secretary of the Mississippi River Commission is carried on under allotments made by the Commission from time to time from appropriations for improving the Mississippi River between the Head of the Passes and the mouth of the Ohio River.

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These allotments are as follows:

(1) *Mississippi River Commission.*—Available for salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission.

(2) *Surveys, gauges, and observations.*—Available for the survey of the Mississippi River between the Head of the Passes and its head waters, for the establishment and maintenance of gauges, for special surveys and examinations, and for the collection and reduction of physical data pertaining to the Mississippi River.

(3) *Dredges and dredging.*—Available for the construction and operation of dredges and dredging plant for the Mississippi River from the Head of the Passes to the mouth of the Ohio River.

(4) *Experimental dikes.*—Available for the construction of experimental low-water dikes at localities below Cairo. This work was transferred to the charge of the secretary from the First and Second districts by resolution of the Mississippi River Commission, 9th March, 1899.

MISSISSIPPI RIVER COMMISSION.

The Mississippi River Commission has held four sessions during the past year, as follows:

Seventy-third session, June 16–18, 1898, at Army Building, New York City.

Seventy-fourth session, December 3–11, 1898, on steamer *Mississippi*, St. Louis, Mo., to New Orleans, La.

Seventy-fifth session, March 7–9, 1899, at Army Building, New York City.

Seventy-sixth session, April 26–May 2, 1899, on board steamer *Mississippi*, St. Louis, Mo., to New Orleans, La.

The committee on dredges met at St. Louis, Mo., August 29, 1899, for consideration of plans for two new dredges. In connection with this subject the committee visited dredges at work under the direction of Maj. T. H. Handbury, Corps of Engineers, near Crystal City, Mo.

Since the last annual report the steamer *Mississippi*, while at St. Louis, during June and July, had new boilers made and set up complete; various minor repairs were made while in winter quarters at West Memphis, Ark.

This boat has carried the Mississippi River Commission on its semiannual inspection trips down the river from St. Louis, Mo., to the Passes in December, 1898, and April–May, 1899, besides making an inspection trip of the river between Cairo and Memphis in August. During September, October, and part of November the boat was in service with the dredging fleet as a general inspection boat. Toward the end of December she towed the dredge *Beta* and barges from St. Louis to the fleet at West Memphis, Ark., where she went into winter quarters.

A recent examination disclosed injuries to some of her bottom plates, caused by collision with submerged logs and other obstructions. She is now in Government dry dock at Keokuk undergoing the necessary repairs.

SURVEYS, GAUGES, AND OBSERVATIONS.

General survey of the Mississippi River.—This survey, which is directed by the law creating the Mississippi River Commission to extend from the Head of the Passes to the head waters of the river, has been carried on in order to obtain sufficient data for accurate topographical and hydrographical maps which may be used in studying the physical characteristics of the river and in planning improvements. The permanent bench marks are also intended to serve as a basis for future surveys, by which means changes in the banks and bed of the river may be ascertained. The most approved methods have therefore been used throughout the work.

The field work consists principally of three parts, viz, secondary triangulation, precise levels, and topography and hydrography.

A description of the surveys of the river to 1896 will be found in the report of the Chief of Engineers for that year, pages 3575 et seq.

This survey now covers the river from the mouth to St. Paul, Minn., a distance of 1,980 miles. The triangulation and precise levels are completed north of St. Paul to Aitkin, Minn.

FIELD WORK OF 1898.

The following is a statement of the field work done during the past year; of the different parts of the survey and their connection with former work:

Secondary triangulation.—This work was extended northward from Minneapolis, Minn., to Aitkin, Minn. The season's work began June 6, 1898, near Fort Snelling, Minn., on the uppermost line of the triangulation of 1895 as a base, and was completed to Aitkin, Minn., November 15, 1898. The river distance covered was about 209 miles. There are 101 triangles in the stretch, with average length of sides of about 4 miles. Ninety-eight stations were occupied; the length and azimuth of a

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base line was determined at each of the following places: Monticello, Rice, Brainerd, and Aitkin. The mean error of closure of the triangles was 1.14 seconds; 130 stone line bench marks were established, and 34 tertiary points, such as church steeples, etc., located. (See plate 1.)

The triangulation party was organized with Asst. Engineer A. T. Morrow in charge and the necessary assistants. The precise-level party, under W. S. Williams, was attached to the triangulation party. The total number of employees was 26, besides 5 teamsters with teams, supplied by contract, for moving the outfit and transporting the subparties to and from their work. The whole party was quartered in a camp of 11 tents, camp being moved as the work progressed.

The country north of St. Paul being generally flat, with considerable timber, it was necessary either to cut lines of sight through the timber or erect high stations; the latter method was found more expeditious and cheaper, and was therefore adopted. The majority of the stations built were from 10 feet to 76 feet in height.

A reconnaissance party, in charge of Mr. George H. French, preceded the triangulation party and selected locations for the stations.

The difficulties of working in the country above Aitkin will necessitate some modifications of methods used below that point.

The cost of the field work has been $18,165.73, which gives an average cost per mile of triangulation and precise leveling of $103.80, or an average per mile of river of $86.92.

The methods used are described in the Report of the Chief of Engineers for 1891, pages 3474 et seq., except the method of observing for azimuth, which was modified as described in the accompanying report of Mr. A. T. Morrow (Appendix 1 C), which also contains details of the season's work.

Precise levels.—This work has been carried from the end of the jetties of the South Pass to Aitkin, Minn., a distance of 2,269 miles, with side lines from Biloxi, Miss., to New Orleans, La., 87 miles; Savanna, Ill., to Chicago, Ill., 148 miles; and Duluth, Minn., to St. Paul, Minn., 156 miles. About 110 miles of this, between Cairo and Helena, was done by the Engineer Department, United States Army, before the creation of the Mississippi River Commission, and the stretch from Greenville, Miss., to Carrollton, La., a distance of 479 miles, was done by the United States Coast and Geodetic Survey in 1879–80, under the Mississippi River Commission. The stretch from Baton Rouge, La., to New Orleans, La., was rerun by the Commission in 1897–98; the stretch from Biloxi, Miss., to New Orleans, La., and from Baton Rouge, La., to Fort Adams, Miss., will be rerun this year. The necessity for this is rendered apparent by the many discrepancies found in the portion rerun in 1897–98; changes in the benches have probably occurred since the first leveling was done. It is the intention to carry the finally adopted mean Gulf level up the river at least as far as St. Louis, Mo.

The levels from St. Paul, Minn., to Aitkin, Minn., were run since the last annual report. Field work began June 6, 1898, and closed November 12. About 197 miles of main line and 25 miles of side lines were completed. The distance by river was about 219 miles.

The precise level bench marks of this stretch are also the stone line bench marks of the left bank. They were set and located by the triangulation party. Their descriptions and the tabulated results of precise leveling are given in the report of Mr. W. S. Williams, surveyor (Appendix 1 D), together with a description of the methods followed by the precise level party and details of the season's work.

Topography and hydrography.—This work has been completed from the Head of the Passes to St. Paul, Minn., a distance of 1,967 miles, and a party is now in the field extending this work above St. Paul, Minn. Field work was begun May 1, 1899, where the work of 1897 ended at the upper limits of St. Paul, Minn. It is expected that the topography and hydrography will be completed during the season to Aitkin, Minn.

SPECIAL SURVEYS.

During the year 1894 low-water surveys from the mouth of the Arkansas River southward were undertaken for the purpose of determining, by comparison with former surveys, the effect of the levees, if any, on the low-water bed of the Mississippi River.

The first surveys extended to Vicksburg, Miss. In 1895–96 they were extended to Donaldsonville, La. In 1897–98 a resurvey was made of that portion between Scot Bluffs (828) and Carrollton, La. (957).

The methods followed in reducing and comparing the results of these surveys are fully described in the Report of the Chief of Engineers for 1896, pages 3577–3592.

At the date of the last Annual Report the information secured during the survey of 1897–98 was not all available for study and comparison. The details of the comparison of the results of these surveys with those of previous surveys are given in the report of Assistant Engineer A. T. Morrow (Appendix 1 C), together with tables

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showing the averages of cross-section elements and the changes in mean cross-section elements so far as they have been determined by the several surveys. (See also Plates 2, 3, 4, and 5.)

The portion of the river covered by these surveys is completely protected by levees; it has comparatively stable banks; at extreme low water it practically subsides to Gulf level. It may therefore be considered a lower-river section, and the conclusions drawn from its examination will properly apply to no other part of the river.

The last survey followed the great flood of 1897. The river was then slightly larger and deeper than at the time of any previous survey.

The comparison of the results of all the surveys seems to show conclusively that there has been a general tendency to the permanent enlargement of the stream above the low-water line, and that the capacity of the river to discharge its flood waters has been more than maintained.

During long periods of comparatively low water, or during several years without a markedly high water, a slight filling probably occurs in the bed of the stream; but during a considerable flood this material is moved and an enlargement of cross section takes place.

The survey of 1895–96, which followed two years of comparatively low water, when compared with that of 1882–83, which followed a flood, shows a decrease in average cross-section area below the low-water line of 5.5 per cent and a decrease in average maximum depth of 6.6 per cent. This same survey of 1895–96, when compared with the survey of 1897–98, shows that after the flood of 1897 the river had increased in area of cross section below the low-water line by 6.6 per cent and in average maximum depth by 8.8 per cent.

The flood of 1897 seemed to make a way for itself by removing material from along the line of the strongest current, making deposits in the slack water about and beyond the banks. Both above and below Donaldsonville the average maximum depth and the area of cross section below the low-water line were considerably increased, while the area of the average cross section above the low-water line was slightly diminished.

GAUGES.

The permanent gauges of the Mississippi River Commission (14 on the Mississippi, 1 on the St. Francis, 1 on the White River, and 1 at Barbre Landing at the head of Atchafalaya River) have been maintained throughout the year. Those on the main river have been inspected twice during the past year. Besides the above a continuous tide gauge has been maintained at Biloxi, Miss. This gauge was established in October, 1895; an excellent record has been secured, covering the time since that date. From this record has been deduced a value for the elevation of mean Gulf level at that point which is recommended for final adoption. The gauge will be continued at least until the completion of another year.

The deduced value for mean Gulf level is a reading of + 6.0829 on the present staff gauge. In reaching this value the half-hourly ordinates were scaled from the tide rolls for 1882 and 1884; the hourly ordinates from the tide rolls for 1895, 1896, 1897, and 1898. From these the mean for each year has been computed, and the mean of these yearly means gives the final value of + 6.0829 mentioned above.

It is of interest to note that the value deduced by using the 1882–1884 record alone is 6.0868; by using the 1895–1898 record alone is 6 0803.

The hydrographs of this gauge, together with those of the Port Eads, East Bay, and Red River Landing gauges, will be found on Plate 8 A sketch map showing the positions of the Biloxi, Port Eads, and East Bay gauges is given on Plate 9.

A discussion of the bearing of these gauge readings upon the question of the possible subsidence of the delta will be found in the report of the Chief of Engineers for 1896, page 3478 et seq. A further discussion of this interesting problem is postponed until after the results of next season's precise level work in this locality are available.

For further details, attention is invited to the report of Assistant Engineer Kivas Tully (Appendix 1 F) and Tables 6 and 7.

In addition to the permanent gauges, high water gauges at intervals of 5 miles from Cairo to Fort Jackson have been maintained. Observations were taken during the last high water. (See Table 8.)

OBSERVATIONS.

Since 1879 a large number of observations for ascertaining the discharges of the Mississippi River and its tributaries have been made at various points during high and low water stages. During the past year it was determined to occupy a station at Thebes, Ill. (45 miles above Cairo), and to select discharge stations on the Cumberland and Tennessee rivers. Hereafter discharge observations will probably not be taken except at extreme high or low water stages.

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PLANT AND OUTFIT.

At the date of the last Annual Report the steamer *Patrol* was at New Madrid, Mo., with the dredging fleet, for care and repairs. During August and September this boat was used as an inspection boat by the assistant engineer in charge of dredging. In November this steamer was placed in commission and used until March, 1899, inspecting the gauges along the river. After completing this work the boat was laid up with the dredge fleet and some minor repairs made where necessary.

The survey boat *Illinois*, after being returned by the Southwest Pass Board, was cared for near New Madrid, Mo., and later moved with the dredge fleet to West Memphis, Ark. This boat has been remodeled for use as an office boat in connection with the dredge fleet.

The steamer *Search* was used for making surveys in connection with dredging, and at the close of the dredging season was laid up with the dredging fleet. The hull of this steamer is in bad condition and will require considerable repair. The boat has been beached at West Memphis and the repairs are in progress.

GENERAL SURVEY PUBLICATIONS.

The following maps have been published by the commission or are now in process of publication:

A map of the lower alluvial valley from Cairo to the Gulf of Mexico, in eight sheets, published in 1887; a new edition of this map showing changes and additions has just been printed.

A map of the alluvial valley of the Mississippi River from Cairo up has been prepared, in 4 sheets; 2 sheets have been published and the other 2 sheets have been sent to the printer.

A district map of the Mississippi River from Cairo to the Gulf of Mexico, showing limits of improvement, levee districts, controlling levees, gauge stations, etc., has been published.

Detail charts of the river, scale 1:20000, showing the topography and hydrography from the Gulf to Spechts Ferry, 632 miles above Cairo, a distance of 1,692 miles, in 145 sheets. During the year 5 new sheets of this map were published and 4 more sheets are now in the hands of the printer.

The inch-to-mile series of maps from the Gulf to the mouth of Galena River, 465 miles above Cairo, a distance of 1,737 miles, in 56 sheets. During the year 2 new sheets were published and 2 more sheets are now in the hands of the printer.

The tabulated results of the survey work have been published in preceding reports of the secretary; the geodetic positions and elevations of permanent marks of the survey from Cairo to St. Paul, Minn., a pamphlet publication of 300 pages, has just been completed.

REDUCTION OF FIELD NOTES.

The following is a brief résumé of the work done by the drafting and topographical division of this office during the past year:

The field notes for the 1897 survey from Brownsville, Minn., to St. Paul, Minn., were reduced and plotted.

The field notes of the precise level line run in 1897-98 between Baton Rouge, La., and South Pass were reduced and the results tabulated, together with descriptions of the bench marks.

The field notes of the secondary triangulation and stone lines from Minneapolis, Minn., to Aitkin, Minn., 1898, were checked, adjustments made, sides computed; L. M. Z's. of secondary stations, tertiary stations, and stone line bench marks computed and tabulated.

The field notes of precise level work from St. Paul, Minn., to Aitkin, Minn., 1898, were reduced, results tabulated, and descriptions of bench marks written.

For a better comparison of cross section elements a large number of sections from Scot Bluffs (829 L) to Carrollton (957) were plotted, areas measured with planimeter, and elements reduced and tabulated.

MAPPING AND DRAWING.

Detail charts Nos. 161–164, covering the river from 603 to 650 miles above Cairo, have been completed.

Detail charts Nos. 165–170 were drawn.

Detail charts 171–175 were about two-fifths drawn.

Inch-to-mile sheets Nos. 125–126 have been drawn.

Sheet No. 4, alluvial valley map of the upper Mississippi, was completed and the color sheet drawn.

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A revision has been made of the lower alluvial valley map (8 sheets), showing the latest controlling levee lines, shore lines from the latest surveys, gauge stations, and river distances and locations below Cairo.

Eleven sets of the 1:20000 scale charts below Cairo have been revised and show all important improvements, levee lines, and shore lines to date.

The drawings accompanying this report have also been prepared.

DREDGES AND DREDGING.

Project.—On the 20th of June, 1896, the Mississippi River Commission adopted a project for obtaining and maintaining, by means of dredges, a channel in the Mississippi River below Cairo, with a width of 250 feet and a depth of at least 9 feet throughout the year, except when the river is closed by ice. This project provided for the construction and operation of seven hydraulic dredges by June 30, 1900, and for the provisional construction of two others if found necessary.

The building of this plant has formed a very important part of the work of this office, has involved the preparation of plans and specifications for the dredges themselves, for the necessary large and small tenders, pile sinkers, and other plant. Since the beginning of the construction of this dredging plant many changes have taken place in the method pursued to procure the most efficient and best designed dredges.

The first dredge was built after plans prepared by the dredging committee, and was in the nature of an experiment. While many changes in this boat were afterwards found necessary, it yet demonstrated beyond a doubt the efficiency of such hydraulic dredges for the purpose for which it was designed.

The next step was to define, in general terms, the conditions which the dredges must fulfill, leaving to the builders the details of the design. Following this course, three dredges were built. Experience was constantly being gained, until a point was reached where it was possible to outline, with greater accuracy, nearly all the details of construction. Under such specifications, two more dredges were built. Under still more rigidly drawn specifications, another, the seventh, to be a self-propelling dredge, is now in process of construction. Drawings and specification for the eighth and ninth dredges (self-propelling) have been prepared and issued.

CONSTRUCTION, ALTERATIONS, AND REPAIRS TO PLANT.

Dredge Alpha.—After completing the capacity tests mentioned in the last annual report, the dredge was laid up at New Madrid and some minor repairs were made to the machinery. Soon after being moved into the field much delay was caused by many stops to repair the main engine. It was found that one of the crank disks of the built-up shaft had twisted on the pin, throwing the whole crank shaft out of line. This made it necessary to take the dredge to Memphis, where extensive repairs were made to the machinery. This work was finished and the engine tested on the 9th of October. After completing the season's work the dredge was laid up, first at New Madrid, Mo. (71), later at West Memphis, Ark. During the winter the machinery was thoroughly overhauled. All of the machinery and the boilers are now in good condition, but the hull leaks badly and must be calked. It is proposed to haul out this dredge before the next low-water season and have the hull put in thoroughly good order.

Dredge Beta.—At the date of the last annual report, this dredge was in the Government dry dock at Keokuk, Iowa, and the contractors (Iowa Iron Works, Limited) were engaged in widening the hull so as to reduce the draft of the boat to about that for which it was originally designed. It was the expectation that the dredge would be available during the low-water season of 1898. Many annoying delays, arising from different causes, occurred, and the work on the hull was not completed until September. The dredge left the dry dock on the 16th of September and toward the end of that month was started to St. Louis, towed by the *Minnetonka*. Owing to the low stage then prevailing in the river, St. Louis was not reached until about the middle of October. Here the cabin work and the remaining alterations were pushed as rapidly as possible, but the dredge could not be completed in time to be of any use in the field. These alterations were practically completed in December, and the dredge was towed from St. Louis to winter quarters at West Memphis. All work contemplated is now about completed, except placing the outfit on the boat. The dredge will probably be tried in June. When fully equipped and under working conditions, the draft of the *Beta* will be about 50 inches, both forward and aft.

Dredge Gamma.—At the close of the dredging season of 1898, and after being laid up in winter quarters, the machinery of this dredge was thoroughly overhauled. An examination of the pump casing disclosed considerable wear. It was determined to fit to the casing easily renewable cast-iron linings which will probably last through at least one dredging season. A design for these linings was made in this office; they were procured and placed in position. The dredge is now in thoroughly good order and ready to go to work.

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Dredge Delta.—Nothing but minor repairs were made to this dredge until after going to work at Island 34. Many delays were caused by the breaking down of the cutter machinery, but these were probably due to the character of the material in which the dredge was working, as described further on in this report. New linings have been placed in the pump, and some changes have been made in the cutter mechanism. The shaft has been cut in two, a new bearing made, and it is proposed to run each half of the shaft separately. New chains are being made for operating the cutters. While the cutter machinery has given considerable trouble in the past, yet it is believed wise to have at least one dredge of the fleet capable of working in material which can not be readily removed by the jet agitators. For this reason it has been determined for the present not to replace the *Delta's* cutters by the water-jet agitators.

Dredges Epsilon and Zeta.—At the date of the last annual report, these two dredges had just been tested and accepted. They proved fairly efficient machines in the field, but after pumping something less than 1,000 hours, the casing of the main pump of the *Epsilon* was found to have been worn entirely through. This damage, which was at first thought to have been caused by some obstruction in the pump, was temporarily repaired in the field. When the dredges were taken to winter quarters a thorough examination was made of the pumps and machinery. The machinery was found to be in excellent condition, but on both the *Epsilon* and *Zeta* phenomenal wear had taken place in the casings of the main pumps. These casings were of good cast iron and were originally about 2 inches thick. In one place the casing of the *Epsilon* had been entirely worn through, and the casing of the *Zeta's* pump was in nearly as bad a condition. It was determined to cut out, on both the pumps, the portions where the wear had been most marked, to replace these parts by cast-iron rings, and in addition, to fit to the casings cast-iron liners. The necessary drawings were made in this office. The rings and linings have been cast and are now being placed in position.

The great and unexpected wear of the pump casings has demonstrated the advisability of providing renewable liners for all pumps which are hereafter to be installed on the dredges.

On account of the numerous breakdowns of the mechanical agitator of the *Zeta*, this mechanism was discarded and a water-jet agitator installed in its place.

Dredge Iota.—The plans and specifications for the *Iota* (the seventh dredge) were completed, the work advertised, and proposals opened on the 22d of July, 1899.

This dredge resembles the *Epsilon* and *Zeta* in general design, but differs from them in that it was determined, on the *Iota*, to place side wheels and propelling machinery, enabling her to move from point to point without the aid of a tender.

The contract for the construction of the *Iota* was let to the Springfield Boiler and Manufacturing Company at their price of $98,820. Certain changes, which were found advisable in the supporting pontons of the pipe lines and the linings, which experience proved to be necessary in the main pump, will increase the contract price of this dredge by about $2,000.

The contract requires this dredge to be delivered on the 26th of August, 1899. Substantial progress has been made by the contractors, and the hull is now practically completed; the main pumping engines and propelling engines are finished; some lumber has been gotten out for the cabin work, and it is hoped that there will be no delay in delivering the dredge in ample time for work during the next low-water season.

Dredges Kappa and Lambda.—Plans and specifications for these two dredges (the eighth and ninth) were completed and issued in April; the work was advertised, and proposals were opened on the 31st of May, 1899. An abstract of the bids received is appended to this report. It has been recommended to award the contract for the construction of the two dredges to the Bucyrus Company, of South Milwaukee, Wis., the lowest bidders, at the price named by them, $244,800, for the two dredges completed in accordance with the specifications. This price does not include the discharge-pipes and their supports. These will be procured under a separate contract.

Both of these dredges are substantially similar to the *Iota*, the only modifications being those which have been dictated by the experience gained during the building of the seventh dredge.

Large steam tenders.—Bids for the construction of five large steel-hull steam tenders were opened on the 27th of May, 1898. The contract for the construction of these boats was awarded to the Iowa Iron Works, Limited, for the sum of $45,672 each. The contract provided for the delivery of all five of these boats on or before the 10th of April, 1899, but owing to various causes the contractors were unable to complete the boats on time. Hull No. 1 was launched on the 17th of April, 1899. Work is progressing with reasonable rapidity and there is a prospect that some of the boats will be ready for use during the coming low-water season.

Small steam tenders.—At the date of the last Annual Report a contract had just been entered into with the M. A. Sweeney Company, of Jeffersonville, Ind., for the

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construction of three small steam tenders, to be delivered by the 10th of September, 1898. Work on these tenders progressed but slowly, and the contractors asked for extension after extension, assigning various pretexts for the delay. The boats were finally completed and delivered at Cairo, Ill., on the 16th of May, 1899.

Pile sinkers.—During the year four pile sinkers were completed and delivered by the Cincinnati Marine Railway Company, of Cincinnati, Ohio. The machinery for these pile sinkers was transferred to this office by the officer in charge of the first and second districts, and three of them were equipped and used during the low-water season of 1898. After the plant was laid up in winter quarters the machinery was installed on the fourth.

Steamer Minnetonka.—At the date of the last Annual Report this boat was at St. Louis, and preparations were being made for placing on board new boilers, which had been found necessary. In September the repairs to the *Minnetonka* were completed and the boat was placed in commission. After that date she was employed with the dredge fleet until all the plant was laid up in winter quarters. Since then some minor repairs have been made to the machinery, and new rudders have been placed on the boat.

Steamer Vidalia.—On the 8th of September this boat struck a snag near Fulton and was retired—laid up at New Madrid—and later towed with the rest of the plant to winter quarters at West Memphis. This boat had been in service for sixteen years; she was thoroughly worn out, has recently been inspected, condemned, and ordered to be sold.

During the past year the supervision of construction and repairs of all plant has been under the charge of Assistant Engineer Thomas Middleton, who has rendered most valuable and efficient service. For further details on this subject, attention is invited to his report (Appendix 1 G).

Painting.—The insides of the hulls of the dredges and the insides and outsides of the pontons have all been thoroughly cleaned and painted.

DREDGING OPERATIONS ON THE LOWER MISSISSIPPI BETWEEN CAIRO, ILL., AND THE HEAD OF THE PASSES, LOUISIANA.

These operations include the care and repair of plant, the testing of dredges, and the operation of the plant during the past low-water season.

A statement of the general principles which have governed the conduct of the dredging operations will be found in the Report of the Chief of Engineers for 1898, pages 3166–3169.

No fixed rules can be laid down for the location of the channels to be dredged. Each case as it arises must be studied with care, and the dredges placed after a thorough examination of the locality and all existing conditions. Success will rarely be attained by the mere inspection of the surface indications. Although some weight should be given to them from the point of view of the pilot, in addition, careful surveys must be made before dredging.

During the low-water season of 1898, the river below Cairo was divided into three districts: first, from Cairo to and including Hathaways Crossing (104); second, from Hathaways Crossing to the head of Island 40 (212); third, from the head of Island 40 as far down the river as dredging should be found necessary. A survey party was placed in each of these districts and preliminary surveys made of all bars where experience indicated dredging might be required. Surveys were also made immediately before dredging at each bar for the purpose of locating the dredge cut; during and after dredging to determine the effect which had been produced. Frequent reports were made to the pilots' associations; buoys were set to mark the channel in difficult places. By permission of the officers in charge of the local light-house district, the positions of the lights were changed to agree with the new channels which were developed. Every effort was made to give full information to steamboatmen and to make the dredging operations of as much value as possible.

The work of each dredge is given in detail below:

Dredge Alpha.—This dredge was placed at Peters Towhead (271) on the 13th of September and attempted to fill the channel across the head of the towhead, and thereby cause more water to flow down the channel to the left. The work was not entirely successful. Dredging continued for ten days, when it was found necessary to stop work and take the dredge to Memphis for repairs to the main engine. After the completion of these repairs the dredge was taken to Island 40 (212) and commenced dredging on the 10th of October. A rising river stopped work on the 14th of this month; it was resumed on the 19th and continued until the 26th, then suspended, and the dredge retired for the season.

Dredge Beta.—This dredge did no work during the low-water season.

Dredge Gamma.—This dredge was placed in position at the chute of Island 40 (213) on the 18th of September. Here the river was obstructed by the wreck of the steamer *City of Hickman*, and there were two indifferent channels, one above and

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one below this wreck. It was decided to attempt to fill the channel above the wreck. Dredging was commenced on the 19th of September and continued until the 26th.

The dredge then left for Wilsons Point, La. (531), arrived there the 3d of October, and in three days' dredging opened an excellent channel across the bar.

The dredge was then taken to Fleeces Crossing (243) and commenced dredging on the 19th of October. Work was continued until the 28th of that month, when it was stopped on account of a rising river.

The dredge was moved to Cow Island Bar (248), where, for four days, she was engaged in making a capacity test, and was then towed to the chute of Island 40 (212), where dredging was begun on the 12th of November and continued until the 16th. A rising river stopped work, and it was not resumed until the 7th of December; it was then continued until the 20th of December, when work for the season was stopped. This last dredging was for the purpose of widening and deepening a cut already made. An immense amount of drift was encountered buried in the sand; 54 logs were removed, varying in diameter from 8 inches to 50 inches and having an aggregate length of over 1,500 feet. While the dredge's outfit is poorly adapted to snag work and it consumed a great deal of time, yet the results obtained warranted the means used. A broad, straight channel was made across the bar, with every indication that it would be maintained.

The dredge was laid up for the winter on the 22d of December.

Dredge Delta.—This dredge was placed in position at Island 34 (179) on the 3d of September; dredging was commenced on the 5th and continued for seventeen days. The material encountered was sand, blue clay, gravel, lignite, logs, stumps, and the wreck of one coal barge containing coal. There were many delays, caused by the breaking of the agitating machinery; for this, the nature of the material encountered is doubtless responsible.

On the 25th of September the dredge commenced filling the old channel along Island 34 (179). In four days' dredging, the depth in this old channel was reduced from 8 feet to 4 feet. A rising river interrupted the work, which was not resumed until the 5th of October, when the channel previously made was widened and deepened. Work was stopped on the 11th of October.

On the 22d of October the dredge commenced working at Mrs. Hickman's Crossing (131) and completed the work on the 24th.

On the 29th of October the dredge was taken to the towhead, foot of Island 13, opposite Cottonwood Point (121¼), where a capacity test was made.

On the 17th of November the dredge was taken to winter quarters and laid up in ordinary.

Dredge Epsilon.—During the entire season this dredge worked in the vicinity of Point Pleasant (79). Near the close of the season a capacity test was made at a bar below Phillips Towhead (81).

Dredge Zeta.—This dredge was at work from the 12th of September until laid up in winter quarters on the 23d of November.

Work was done at Mrs. Hickmans Crossing (131), at Elmot Bar (161), at Island 34 (179), and at Cherokee Crossing (89).

A capacity test was made at Cherokee Bar.

A summary of the dredging operations, together with the cost and the distribution of expenditures, will be found in Tables 10, 11, 12, and 13.

CAPACITY TESTS OF DREDGES.

At the close of the dredging season, before assembling the fleet in winter quarters, an effort was made to determine the working capacity of the several dredges (with the exception of the *Alpha* and *Beta*) under actual field conditions.

In the tests made at the time of the acceptance of these dredges, a measurement of the material moved was made by deflecting the discharge stream for a short interval of time into a barge and then measuring the material so delivered. The time interval was necessarily short, averaging, perhaps, but little over a minute for each test. A small error in reading would seriously affect the computed capacity per hour. This method is also open to the more serious objection that the resulting determination of the quantity of material removed is based upon the assumption that the conditions existing at that particular time will be continuous, which hardly seems warranted by experience.

In the recent tests, an effort was made to obtain the working capacity of the dredges in clean sand and in water without current, where all the material removed during the continuation of the test must be moved by the dredge alone. Great care was taken in selecting suitable localities for making the tests. Careful surveys were made just before and immediately after the conclusion of the dredging. Every possible precaution was taken to secure accuracy in the calculation of the amount of material moved. It is believed that the results obtained give more closely than any

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other method which could be employed, the actual capacity of the dredges under ordinary working conditions.

Dredge Gamma.—The duration of the test of this dredge was 45 hours and 30 minutes actual dredging. The total volume of material removed was 45,856 cubic yards, a rate of 1,008 cubic yards per hour.

Dredge Delta.—The duration of the test of this dredge was 27 hours and 23 minutes actual dredging. The total volume of material removed was 34,262 cubic yards, a rate of 1,259 cubic yards per hour. This material was removed from four cuts. While making the first two cuts no attempt was made to crowd the dredge at all. On the third cut the dredge was pulled ahead faster, and on the fourth cut the rate of advance was as high as could be maintained without sinking the discharge pipe. While making this fourth cut the dredge worked at the rate of about 2,550 cubic yards per hour. This rate might have been exceeded had the pontons been able to carry away more dredged material.

Dredge Epsilon.—The duration of the test of this dredge was 24 hours and 50 minutes. The volume of material removed was 32,407 cubic yards, a rate of 1,305 cubic yards per hour.

Dredge Zeta.—The test of this dredge differed from those just described, as it was decided, in addition to the capacity test, to determine the practicability of dredging through a dry bar. At the point selected for the test the bar was bluff, and about 4 feet above the water surface. The head cables were attached to deadmen placed on the dry bar. The duration of the test was 62 hours and 55 minutes actual dredging. Six cuts were made, having a total length of 1,785 feet. A hole was cut in the dry bar approximately 500 feet long, 140 feet wide at top, and having a depth of from 3½ feet to 4 feet above and 13 feet below water along the axes of the cuts. It would have been entirely practicable to have cut a channel clear across the bar to the deep water on the opposite side. The total volume of material removed was 40,941 cubic yards, a rate of 652 cubic yards per hour. The lesser capacity thus indicated was probably due to the conditions under which the dredge was working and to the material encountered. The bar above water, and for a depth of about 7 feet below the water surface, was pure sand; beneath this was a layer of blue mud extending down at least as deep as the point to which the suction head was lowered—from 16 to 17 feet.

From the records kept during the dredge tests, a summary has been compiled which will be found in Table 14.

In computing the matter of cost, the items of fuel, pay rolls, subsistence, lubricants, lighting supplies, and repairs, were taken into account. The cost of the hire of the tender was not included.

Plates 37–40 show the plotted results of the surveys and some characteristic cross sections before and after the test of the *Gamma*.

For further details on this subject, attention is invited to report of Asst. Engineer F. B. Maltby (Appendix 1 H).

DISCUSSION OF RESULTS.

Before taking up in detail the results of the dredging operations it is well to call attention to the fact that at no time during 1898 was there a period of extreme low water. Some of the lowest gauge readings during the year were as follows: Cairo, October 10, 7.67 feet; Fulton, October 11, 6.55 feet; Memphis, October 12, 4.50 feet. In 1895, a year of unusually low water, the lowest readings on these gauges were: Cairo, November 6, 1.10 feet; Fulton, November 7–8, 0.16 foot; Memphis, November 6–9, — 2.65 feet. An inspection of the hydrographs on Plate 7 shows that the crests of small rises followed each other down the river at short intervals of time during the fall months, the usual low-water season.

It does not necessarily follow that there were proportionately greater depths on the shoal crossings in 1898; it is well known that under the conditions then prevailing, less depths are frequently found on the crossings than exist during a time when the river is stationary or slowly falling and much lower readings are recorded on the gauges.

The bars where work was done were carefully surveyed before, during, and after dredging. The results are shown on Plates 10–36, where depths greater than 9 feet are indicated by parallel ruling.

Vicinity of Point Pleasant (81–83).—This has always been one of the most difficult portions of the river; in recent years, boats have experienced more trouble here than at any other locality; the shoal crossings are close together; there are numerous side channels leading into dead pools. These conditions make the proper locations of the channels to be dredged matters of more or less difficulty. The results of the first survey of the season are shown on Plate 10. At the time of this survey the pools and crossings are distinctly outlined. Later, it was found that the crossings had, as usual, moved downstream. The areas dredged and the effects of the dredg-

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ing at Upper Point Pleasant Crossing, just opposite the town, are shown on Plates 11, 12, 13, 14, and 15, the surveys having been made at different times during the season. None of the surveys shows a very well defined channel as the result of the dredging; still at no time was there less than 10 feet on this crossing.

An attempt was made to fill the chute back of the towhead which extends some distance above the upper limit of the map on Plate 10. Considerable material was pumped into this chute, but it had little effect on the volume of water, as the current seemed to be simply deflected against the bar, where sufficient scour took place to offset the filling.

Laxelles Crossing (83), Plates 16 and 17.—Here was a case of overlapping pools. A channel of fair width and good depth was readily opened along the right bank of the river. It required no further attention, but remained in existence and in use until the end of the season.

Mrs. Hickmans Crossing (131).—Plates 18 and 19 show clearly the conditions existing here before and after dredging. No trouble was experienced at this crossing during the year.

Elmot Crossing (161).—Plates 20 and 21 show the conditions before dredging. Along the right bank there was a narrow and somewhat difficult channel, while a deep pool existed along the front of Elmot Bar. After a study of the conditions it was decided to make no attempt to improve the right bank channel, but to dredge across the ridge separating this deep water from that along the bar. The effect of the dredging is shown on Plate 22. The results were satisfactory; the channel was opened but once; it remained in good condition throughout the season, with no less depth than 12 feet.

Island 34 (179).—Plates 23 and 24 show the results of surveys in this vicinity before dredging; Plates 25 and 26 after dredging. As noted elsewhere, the material encountered was exceedingly difficult to remove. Once opened, a channel of ample depth was maintained, though a slight filling, which had to be removed, occurred near the lower end.

Island 40 (213), Plates 27, 28, 29, and 30.—A very successful attempt was made to fill the upper channel which early in the season existed above the wreck of the *City of Hickman*. This channel was completely closed; a bar, nearly dry at low water, formed and extended from shore clear out to the wreck. A straight channel was then dredged on the island side of the river directly in line with the current; much buried drift was encountered and removed; an excellent channel was opened which remained in existence and improved until the close of the season.

Fleeces Crossing (243), Plates 31, 32, and 33.—The *Gamma* worked at this locality between the 19th and 28th of October. Owing to an accident to the machinery, part of the time dredging was done without the use of the jet. Some shoaling occurred, but the last survey, December 1, shows that while the channel had shifted slightly it had cut out more and was of good width and depth.

Wilsons Point (531), Plates 34, 35, and 36.—Four days' dredging—October 4-7—deepened the channel across the bar from 9 to 15 feet at low water. Boats commenced using the channel at once and continued to run it without difficulty until the end of the low-water season. Plate 36 shows the results of a survey made fifty-four days after dredging. The channel was still clearly defined, though some shoaling had taken place below it.

In general, it may be said that there was no interruption to navigation during the year 1898; there were greater available depths on the crossings than had been found for a number of years; the dredges never failed to promptly open a good channel across any bar they attacked; these channels were usually easily maintained; most of them enlarged and remained open until after the close of the dredging season.

For additional details, see report of Asst. Engineer F. B. Maltby (Appendix 1 H), who rendered most valuable service as superintendent of dredges and dredging.

EXPERIMENTAL DIKES.

The charge of this work was transferred to this office by resolution of the commission March 9, 1899; a project has been submitted and approved; steps have been taken to secure the necessary plant and construction material; no field work was done and none will be undertaken until the river falls to a lower stage.

COMMERCIAL STATISTICS.

It is practically impossible to obtain reliable statistics of the commerce on the Lower Mississippi River unless special agents are employed for their collection.

The following papers accompany this report:

Money statement.

Abstracts of all proposals, in order of date of opening bids.

List of contracts in force, with names of contractors, dates of approval, dates of beginning work, and dates of completion.

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Statement of charts issued and sold.
List of civilian engineers.
Approximate value of plant.
Appendix 1 A, laws affecting the Mississippi River Commission, July 1, 1898, to June 30, 1899.
Appendix 1 B, specifications for the construction of the dredge *Iota*.
Appendix 1 C, report of Asst. Engineer A. T. Morrow on survey work north of St. Paul, Minn., and on comparison of the results of low-water surveys on the lower river.
Appendix 1 D, report of Surveyor W. S. Williams on precise level work north of St. Paul, Minn.
Appendix 1 E, instructions for precise level work.
Appendix 1 F, report of Asst. Engineer Kivas Tully on gauges, reduction of physical data, and office publications.
Appendix 1 G, report of Asst. Engineer Thomas Middleton on repairs to plant and construction of new plant.
Appendix 1 H, report of Asst. Engineer F. B. Maltby on dredging operations, tests of dredges, care and repair of plant.
Respectfully submitted.

MASON M. PATRICK,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. Army,
President Mississippi River Commission.

Money statement.

July 1, 1898, balance unexpended		$701,750.26
Amount allotted from appropriation by sundry civil act of July 1, 1898	$513,400.00	
Amount allotted from appropriation by sundry civil act of March 3, 1899	513,400.00	
Amount transferred by officer in charge First and Second districts (allotment for experimental dikes)	16,071.02	
		1,042,871.02
		1,744,621.28
June 30, 1899, amount expended during fiscal year		479,665.62
July 1, 1899, balance unexpended		1,264,955.66
July 1, 1899, outstanding liabilities	$38,256.42	
July 1, 1899, amount covered by uncompleted contracts	298,787.55	
		337,043.97
July 1, 1899, balance available		927,911.69
Amount that can be profitably expended in fiscal year ending June 30, 1901		650,000.00

Abstract of proposals for furnishing a self-propelling hydraulic dredge, received in response to advertisement dated June 21, 1898, and opened by Capt. H. E. Waterman, Corps of Engineers, on July 22, 1898.

No.	Name of bidder.	For self-propelling hydraulic dredge.	Extra for refrigerating plant.
1	The Springfield Boiler and Manufacturing Co., Springfield, Ill.	a $94,970.00	$2,980.50
2	Edward Flad, St. Louis Mo.	98,981.00	2,300.00
3	The Bucyrus Co., South Milwaukee, Wis.	129,759.75	2,448.00

a Bid for self-propelling hydraulic dredge at $94,970 accepted, with additional allowance of $3,850 for substitution of 1 Worthington or Blake air pump and condenser in place of the Stillwell-Bierce and Smith-Vaile; 1 Worthington or Blake jet pump in place of the Stillwell-Bierce and Smith-Vaile; 2 Worthington or Blake feed and fire pumps in place of the Laidlaw-Dunn-Gordon.

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Abstract of proposals for furnishing coal for dredging operations, received in response to advertisement dated February 13, 1899, and opened by Capt. Mason M. Patrick, Corps of Engineers, March 15, 1899.

No.	Name of bidder.	Kind of coal, name and location of mine.	Quantity.	Price per bushel.	Total cost.
			Bushels.	*Cents.*	
1	Cairo City Coal Co., Cairo, Ill.	Hallidayboro mine, Hallidayboro, Jackson County, Ill.	350,000	.9	$31,500
a2	Frederick Hartweg, Cincinnati, Ohio.	Catsburg mine at Catsburg, Elizabeth mine at Elizabeth, Ivill mine at Catsburg, all on Monongahela River, Pa.	350,000	9.9	34,650
		Cedar Grove, Belmont, and Coalburg mines, Coalburg, Kanawha River, W. Va.	350,000	9.9	34,650
		Chesapeake mine, Handley, Kanawha River, W. Va.	350,000	9.9	34,650
		Black Diamond mine, Lewiston, Kanawha River, W. Va.	350,000	9.9	34,650
3	Samuel S. Brown, Pittsburg, Pa.	Youghiogheny mines, No. 1 and No. 2, on Youghiogheny River, near Pittsburg, Pa.	350,000	10.5	36,750

a Accepted.

Abstract of proposals for furnishing two hydraulic dredges for dredging operations under Mississippi River Commission, received in response to advertisement dated April 19, 1899, and opened by Capt. Mason M. Patrick, Corps of Engineers, May 31, 1899.

No.	Name of bidder.	For one dredge.	For two dredges.	Remarks.
1	The Bucyrus Co., South Milwaukee, Wis.	.....	$244,800	Deduct $2,000 from amount of bid if Prescott pumps can be substituted for the Worthington or Blake pumps where specified. Recommended for award at price stated, with Worthington pumps. Contract awarded as recommended.
2	The Springfield Boiler and Manufacturing Co., Springfield, Ill.	$125,536	244,980	Deduct $4,500 from net price for two dredges if same main pumps and engines as furnished for U. S. dredge *Iota* can be substituted. Add $200 if refrigerating plant on specifications of Westinghouse, Church, Kerr & Co. is accepted, with further additional price of $250 if distilling apparatus for refrigerating plant is furnished.
3	Iowa Iron Works, Limited, Dubuque, Iowa.	129,140	256,780	

Abstract of contracts entered into by Capt. H. E. Waterman and Capt. Mason M. Patrick, Corps of Engineers, in force June 30, 1899—Improving Mississippi River, Mississippi River Commission, secretary's office.

Contract for—	Contractor.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration of contract.
		1898.	1898.	1898.	
Coal	Frederick Hartweg	Mar. 28	June 10	July 1	June 30, 1899.
Five steam tenders	Iowa Iron Works, Limited.	June 10	Aug. 22	June 20	Apr. 10, 1899, extended to Sept. 1, 1899.
Self-propelling hydraulic dredge.	The Springfield Boiler and Manufacturing Co.	Aug. 26	Nov. 14	Sept. 5	Aug. 26, 1899.

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Statement of maps and charts issued and sold from July 1, 1898, to June 30, 1899.

Description.	Free.	Sold.	Total.
Upper alluvial valley map	5	9	1
Lower alluvial valley map	56	297	35
Inch-to-mile map	673	829	1,50
Detail chart, 1:20,000 scale	2,001	322	2,32
Detail chart, 1:10,000 scale (harbor of New Orleans)	4	28	3
District map of Lower Mississippi River	3	6	
Total	2,742	1,491	4,23

Proceeds deposited with assistant treasurer of the United States at St. Louis, Mo. $154.92.

List of civilian engineers employed on works of the Mississippi River Commission in charg of the secretary, from July 1, 1898, to June 30, 1899.

Name and residence.	Time employed.		Pay per month.	Where employed.	Work on which employed
	Mos.	*dys.*			
Thomas Middleton, St. Louis, Mo.	12	0	$200	Secretary's office ...	In charge of designing an construction of plant.
F. B. Maltby, St. Louis, Mo.....	9	12	200	In field	In charge of dredging o erations.
C. W. Sturtevant, Appleton City, Mo.	2	12	200	.....do	Do.
A. T. Morrow, Rockford, Ill.....	12	0	175	In field and secretary's office.	Surveys.
Kivas Tully, St. Louis, Mo.....	12	0	175	In secretary's office.	Computing division.
C. W. Clark, Webster Groves, Mo.	12	0	175	.....do	Mapping division.
E. H. Twining, New York, N. Y.	12	0	175	President's office ...	Reports and estimates.
W. G. Comber, St. Louis, Mo	12	0	150	In field and secretary's office.	Surveys.
Geo. H. French, St. Louis, Mo ...	12	0	145	.....do	Do.
Wm. Gerig, New Orleans, La....	1	6	150	In field	Experimental dikes.

Approximate value of plant belonging to the United States used on works under the Missi sippi River Commission, in charge of Capt. Mason M. Patrick, Corps of Engineer secretary.

Class of property.	Present approximate value.	Class of property.	Presen approx mate value.
Dredge Alpha	$48,600	Steamboat Venus	$7,
Dredge Beta	227,500	Steamboat Mars	7,
Dredge Gamma	72,000	Barges	4,
Dredge Delta	90,000	Pile sinkers	14,
Dredge Epsilon	94,500	Survey and quarter boats	2,
Dredge Zeta	94,500	Flatboats, skiffs, and rowboats	1,
Steamboat Mississippi	45,000	Diving outfit	
Steamboat Minnetonka	10,800	Surveying instruments, photographic	
Steamboat Patrol	9,000	outfit, office furniture, books, etc...	8,
Steamboat Search	6,300		
Steamboat Vulcan	7,080	Total	759,
Steamboat Mercury	7,749		

APPENDIXES ACCOMPANYING THE REPORT OF CAPT. MASON M. PATRICK, CORPS ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

A. Laws affecting the Mississippi River Commission, July 1, 1898, to June 30, 18
B. Specifications for the construction of the dredge *Iota*.
C. Report of Assistant Engineer A. T. Morrow on survey work north of St. Pa Minn., and on comparison of the results of low-water surveys on the lower river.
D. Report of Surveyor W. S. Williams on precise level work north of St. Paul, Mi
E. Instructions for precise level work.

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F. Report of Assistant Engineer Kivas Tully on gauges, reduction of physical data, and office publications.

G. Report of Assistant Engineer Thomas Middleton on repairs to plant and construction of new plant.

H. Report of Assistant Engineer F. B. Maltby on dredging operations, tests of dredges, care and repair of plant.

LIST OF PLATES ACCOMPANYING THE ANNUAL REPORT OF CAPT. MASON M. PATRICK, CORPS OF ENGINEERS, U. S. A., SECRETARY MISSISSIPPI RIVER COMMISSION, FOR FISCAL YEAR ENDING JUNE 30, 1899.

PLATE 1.—Map of secondary triangulation and stone line bench marks from St. Paul, Minn., to Aitkin, Minn.

PLATE 2.—Map showing location of cross sections, Scot Bluffs to Donaldsonville, La., comparison of surveys of 1895–96 and 1897–98.

PLATE 3.—Map showing location of cross sections, Donaldsonville to Carrollton, La., comparison of surveys of 1893–94 and 1897–98.

PLATE 4.—Cross section elements, Scot Bluffs to Donaldsonville, La., surveys of 1895–96 and 1897–98.

PLATE 5.—Cross section elements, Donaldsonville to Carrollton, La., surveys of 1893–94 and 1897–98.

PLATE 6.—Profiles, high and low waters, Cairo, Ill., to Fort Jackson, La., 1898–99 and earlier years.

PLATE 7.—Hydrographs, Cairo, Ill., to Carrollton, La., June 1, 1898, to June 1, 1899.

PLATE 8.—Hydrographs, Biloxi, Port Eads, East Bay, and Red River Landing.

PLATE 9.—Map showing location of tide gauges at Biloxi, Port Eads, and East Bay.

PLATES 10–40.—Maps of certain localities below Cairo where dredging was done during low-water season of 1898, as follows:

10–15.—Point Pleasant Bar.
16–17.—Lazelles Bar.
18–19.—Hickmans Crossing.
20–22.—Elmot Bar.
23–26.—Island 34.
27–30.—Island 40.
31–33.—Fleeces Crossing.
34–36.—Wilsons Point.
37–40.—Tests of dredge *Gamma* at Cow Island Bar.

PLATE 41.—Dredge *Iota*. Longitudinal sectional elevation, showing general arrangement of machinery, etc.

PLATE 42.—Dredge *Iota*. Plan of main deck, showing general arrangement of machinery, etc.

APPENDIX 1 A.

LAWS AFFECTING THE MISSISSIPPI RIVER COMMISSION, JULY 1, 1898, TO JUNE 30, 1899.

[PUBLIC—NO. 176.]

AN ACT Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-nine, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, eighteen hundred and ninety-nine, namely:

* * * * * * *

UNDER THE WAR DEPARTMENT.

* * * * * * *

ENGINEER DEPARTMENT.

* * * * * * *

Improving Mississippi River: For continuing improvement of Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission, one million nine hundred and eighty-three thousand three hundred and thirty-three

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dollars, of which the sum of twenty thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, in protecting the bank at and near the town of Caruthersville, Missouri; the sum of one hundred thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, in the rectification of the banks at Greenville, Mississippi; the sum of thirty thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, for the completion of the revetment work at or near the town of Helena, Arkansas; the sum of thirty-five thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, for the completion of the revetment work along the bluff at the harbor of Memphis, Tennessee; the sum of ten thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, for repairing the damage which was done by the flood of eighteen hundred and ninety-seven to the revetment work which was built by the United States Government in eighteen hundred and ninety-five along the bluff at said harbor of Memphis, Tennessee; and the sum of fifty thousand dollars, or so much thereof as may be necessary, shall be used, in the discretion of the Secretary of War, for continuing improvement of the Mississippi River at New Madrid, Missouri, revetment of the banks, and preventing destruction of the same.

* * * * * * *

Approved July 1, 1898.

[PUBLIC—No. 188.]

AN ACT Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, nineteen hundred, namely:

* * * * * * *

UNDER THE WAR DEPARTMENT.

* * * * * * *

ENGINEER DEPARTMENT.

* * * * * * *

Improving Mississippi River: For continuing improvement of Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission, two million five hundred and eighty-three thousand three hundred and thirty-three dollars: *Provided,* That of said sum fifty thousand dollars shall be used in the work of rectifying the bank at and near Greenville Harbor, in Mississippi; thirty-five thousand dollars shall be used in rectifying the banks at and near the city of Caruthersville, Missouri; forty thousand dollars shall be used for completing revetment work at New Madrid, Missouri; and thirty thousand dollars shall be used in improving the harbor and rectifying the banks at and near Helena, Arkansas.

* * * * * * *

Approved March 3, 1899.

[PUBLIC—No. 189.]

AN ACT Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums of money be, and are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be immediately available, and to be expended under the direction of the Secretary of War and the supervision of the Chief of Engineers, for the construction, completion, repair, and preservation of the public works hereinafter named:

* * * * * * *

For work in accordance with the plans and specifications of the Mississippi River Commission:

At the harbor of New Orleans, Louisiana: Continuing improvement, one hundred and ten thousand dollars.

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At the harbor of Natchez and Vidalia, Mississippi and Louisiana, fifty thousand dollars.

At the harbor of Memphis, Tennessee: The Mississippi River Commission is directed to examine the harbor at Memphis, Tennessee, and report what improvement, if any, should be made to remove the bar in front of the city of Memphis, together with the cost thereof.

For rectification of Red and Atchafalaya rivers, Louisiana: Continuing improvement, twenty-five thousand dollars.

* * * * * * *

Approved March 3, 1899.

APPENDIX 1 B.

SPECIFICATIONS FOR CONSTRUCTION OF SELF-PROPELLING HYDRAULIC DREDGE IOTA, FOR MISSISSIPPI RIVER COMMISSION.

* * * * * * *

SPECIAL CONDITIONS.

34. General.—The work to be contracted for under these specifications is the building of the hull, cabins, dredging and propelling machinery of one self-propelling dydraulic dredge and of five hundred (500) feet of floating discharge pipe with pontons; together with such parts and appurtenances as are hereinafter described, and shall comprise all the materials, tools, labor, etc., of every description requisite and necessary for the proper and entire completion and delivery of the same.

35. Proposals.—Proposals will be received for one dredge complete as hereinafter described, exclusive of the refrigerating plant, with an additional and separate price for the refrigerating plant as called for in these specifications. The right is reserved to accept or reject any or all bids or parts thereof, and to make award as may be deemed most advantageous to the United States.

36. Bidders' and contractor's drawings, etc.—Bidders must submit with their proposals such drawings in triplicate as will illustrate the machinery which they propose to furnish and which do not form part of the drawings supplied by the United States; more particularly those of the main engines and pump, side-wheel engines, condenser and air pump and jet pump, and also a general plan of the refrigerating plant, together with specifications in triplicate giving full description of the above parts. A copy of these specifications should be attached to each copy of the proposal and be referred to therein. The drawings need not be attached to the proposal, but should be referred to therein. The successful bidder will be required to furnish seven (7) copies of these drawings and specifications to complete the contract. The contractor must also submit to the engineer officer in charge for approval, any and all working drawings that may be required in the prosecution of the work that are not furnished by the United States. A complete set of the tracings of these working drawings must also be furnished and delivered at the office of the secretary, Mississippi River Commission, St. Louis, Mo., upon completion of work and prior to the final payment.

37. Quality of material.—Except it be otherwise specified, all materials are to be of the best quality of their respective kinds, and all labor is to be done in a most thorough, prompt, and workmanlike manner, to the full satisfaction of the engineer officer in charge. In all cases where an article is mentioned, preceded, or followed by the words "or equal," "best quality," "approved quality or make," "or other equally good," or words of like purport, the engineer officer in charge will decide as to the best and most suitable article to be used.

38. Inspection.—Inspectors will be appointed by the United States to supervise the work, and the contractor must at all times give them access to the work and full facilities for examination of all material and workmanship. Such tests of material as are deemed necessary are to be made at the expense of the contractor under the supervision of the inspectors. The engineer officer in charge shall have the right to require the immediate removal of any employee of the contractor who is deemed incompetent or otherwise objectionable.

39. Extra work.—It is the intent of these specifications to secure to the United States a dredge of first-class construction, complete in all respects for the work it is designed to do, and ready for operation. No claim whatever shall at any time be made upon the United States by the contractor for or on account of any extra work or materials performed or furnished, or alleged to have been performed or furnished, unless such extra work or materials shall have been expressly required in writing by the engineer officer in charge, the prices and quantities thereof having been first agreed upon by the contracting parties and approved by the Chief of Engineers.

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40. Patents.—The contractor shall guarantee the Government against any claims or awards for damage on account of the infringement of any patented device which he shall furnish the dredge.

41. Omissions, etc.—All necessary adjuncts, parts, or attachments properly forming a part of the dredge and requisite for the proper and efficient working of the machinery shall be understood to be included in these specifications, whether mentioned herein or not, and shall be supplied by the contractor as forming part of the contract. Any doubt as to the meaning of these specifications, or of any drawings or explanations which are furnished the contractor, will be explained by the engineer officer in charge, who shall also have the right to correct any errors in said specifications, etc., when such correction is necessary for the proper fulfillment of their intention.

42. Delivery.—The dredge must be all completed in every part and delivered to the engineer officer in charge at Cairo, Illinois, for test, within twelve (12) months from the date of notification of award of contract. Upon notification being received that the dredge is ready for delivery, the engineer officer in charge will direct a preliminary inspection to be made to determine whether everything is complete and in proper working order, and the tests will not be proceeded with unless all parts of the dredge plant, tools, and accessories are deemed by said engineer officer in charge to be practically complete in accordance with the terms of these specifications. Delivery for test will not be deemed accomplished however, until the completion in a satisfactory manner of the contractor's test prescribed below. If there be no delay caused by defective material or bad workmanship during the subsequent Government test beyond that hereinafter authorized, the date of the commencement of this Government test will be considered as the date of delivery of the dredge. Should, however, there be delays from the above causes, the date of delivery will be taken as that on which a successful Government test is begun.

43. Penalty.—In case of failure to complete and deliver the dredge within the time specified, the contractor will be liable and must pay any and all expenses incurred by the United States because of said failure, said expenses to be determined by the engineer officer in charge.

44. Contractor's test.—When the preliminary inspection is satisfactorily completed the contractor will be required, before beginning the Government test, to make an endurance test of his own. This will consist in running the main engines and pump at a velocity of 175 revolutions per minute, during a continuous period of ten (10) hours while pumping water through 500 feet of discharge pipe, the other machinery being run at the same time at its full working speed. Before this test the dredge will be moved to such point in the river near Cairo, Illinois, as the engineer officer in charge may select, and will remain anchored by the spud during test. This test must be run at the sole expense of the contractor. During the same full records of the running of all machinery will be taken by the authorized agents of the engineer officer in charge, but the contractor will have full control of the working of all machinery. Should this test not be successful, other tests on the same plan must be made until the machinery will satisfactorily perform the requirements.

45. Government test.—When the contractor's test is successfuly completed, the Government efficiency test will be made under the direction of the engineer officer in charge, with his own employes. This test will consist in operating the dredge under actual working conditions, with the main engines and pump running at about 160 revolutions per minute, and all the other machinery at the requisite working capacity, for a period of five (5) days, either continuously night and day or for any less period, at the option of the engineer officer in charge. During this test the pipe line may be increased to 1,000 feet and capacity tests taken and the dredge maneuvered in any way the engineer officer in charge may deem advisable, but the main engines will not be run above 165 revolutions, the steam pressure carried will not exceed 170 pounds per square inch, and the dredge will not be forced into the cut beyond a fair working speed, according to the face of bank ahead. Full records of this test will be taken, and the time of stoppages for repairs due to defective material or bad workmanship must not exceed fifteen (15) per centum of the time spent in actual dredging. Any minor repairs needed during this test which can be done on board will be done at the expense of the United States, but the cost of all other repairs must be borne by the contractor. During the Government test the contractor and his authorized representatives will be taken care of aboard the dredge, but will not be allowed to give any orders to any of the crew without the consent of the agent of the United States in charge.

46. Towing test.—To test the working of the propelling engines the dredge will make a trip of four (4) hours' duration upstream, and return, with one pile sinker, one coal barge partially loaded, and all the pipe line in tow. The engines will be run full speed with various rates of cut-off, and full records taken.

47. Other tests.—If the Government efficiency test above described proves unsatisfactory, the engineer officer in charge may continue the tests for such period as he may find advisable in order to obtain the desired results.

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48. Final inspection.—Immediately after the conclusion of the tests all parts of the dredge plant furnished by the contractor will be given a thorough examination under the direction of the engineer officer in charge, and if any repairs are found necessary to the machinery which are not properly chargeable to fair wear and tear, the contractor will be required to put the same in proper working order. He will also complete the painting and turn over the drawings as specified in paragraphs 184 and 36. The engineer officer in charge may, however, if he deems advisable, waive these requirements and accept the dredge, deducting from the contract price sufficient to cover the cost of making good any deficiencies determined by the final inspection.

49. Payments.—When the hull is finished, wheel beams, bridge trees, and cylinder beams in place, ready for machinery, and said hull successfully launched, twenty (20) per centum of the contract price will be paid. After the launching and the payment of the twenty (20) per centum, monthly payments will be made on estimates of the engineer officer in charge or his authorized agents of the value of the work completed and in place. Twenty (20) per centum of the contract price will be retained until after the testing, final inspection, and acceptance of the dredge, to cover the cost of any alterations or deductions found necessary.

50. Ownership.—All parts paid for under the system of partial payments above specified shall become thereby the sole property of the United States; but this provision shall not be interpreted as relieving the contractor from the sole responsibility for the proper care and protection of said parts prior to delivery of the dredge to the United States or from any other of the provisions of these specifications.

DETAILED SPECIFICATIONS.

51. Description.—This dredge is designed to have a single sand-pumping outfit and also to be self-propelling. The hull is to be of steel throughout, with guards extending to outside of paddle boxes, the knuckles rounded, the bow and stern to be made with long rakes, the usual suction well to be built in bow and towing knees at head, and is estimated to have a draft of 48 inches when fully equipped. The pumping machinery will consist of a centrifugal pump with 32-inch discharge pipes, and will be capable of delivering not less than 1,000 cubic yards of sand per hour through 1,000 feet of pipe under average field conditions. This pump will be driven by a pair of horizontal tandem compound condensing engines, good for running at 175 revolutions per minute. The sand agitator will be of the water-jet type, supplied with water at pressure ranging from 60 to 100 lbs. per square inch by a duplex compound plunger pump. The feeding into cut will be done by wire rope haulage similar to that adopted for all dredges of the commission. The pipe line will be 500 feet long, in sections of 50 feet, each carried by a pontoon and arranged with swivel movement to permit of their swinging to the current. The propelling machinery will consist of two side paddle wheels, each 21 feet diameter and 10½ feet long, driven by engines of the Mississippi River type. The steam plant will consist of seven Mississippi River four-flued boilers set in three batteries and built for a working pressure of 170 lbs. per square inch. The condenser and air pump will be of the Independent type, and the dredge will be provided with steam steering apparatus and all accessories for working both as a dredge and a steamboat.

52. Drawings.—The drawings furnished by the United States are those prepared in the office of the secretary Mississippi River Commission, and are indexed and catalogued as $\frac{\text{M. R. C.,}}{1049}$. The numbers and titles of the sheets are as follows:

Sheet 1. Lines of hull.
Sheet 2. Main deck plan.
Sheet 3. Boiler deck plan.
Sheet 4. Longitudinal section.
Sheet 5. Cross section of hull and cabin.
Sheet 6. Details of hull.
Sheet 7. Wheel beams and bridge trees.
Sheet 8. Paddle boxes.
Sheet 9. Cylinder beams, etc.
Sheet 10. Suction head.
Sheet 11. Radial joints.
Sheet 12. Hoisting frame.
Sheet 13. Swivel elbow for discharge.
Sheet 14. Hauling winches.
Sheet 15. Hoisting winch.
Sheet 16. Spud-lifting cylinder.
Sheet 17. Ponton for discharge pipes.

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HULL.

53. General dimensions:

Length molded	192′ 0″
Width molded	44′ 0″
Depth molded	7′ 0″
Width at bow	32′ 0″
Width at stern	34′ 0″
Width over guards outside of nosing	70′ 0′
Length of well	33′ 0″
Width of well at nose	25′ 0″

54. Framing.—The dredge is to be framed on the transverse system, with six transverse bulkheads, two collision bulkheads in wings, and four longitudinal truss frames. The frames are numbered from the bow, which is zero, to the transom, which is No. 128, and will be referred to in these specifications by these numbers. The frames are spaced at a uniform distance apart of 18 inches. The even numbered frames from 26 to 108, inclusive, are of 2½ in. × 2½ in. × 5 lb. angle bar, with floor plates 8 inches wide and $\frac{3}{16}$ inch thick riveted to the standing flange, on the top edges of which reverse frames of 2½ in. × 2½ in. × 5 lb. angle bar are riveted, extending up the turn of bilge to a vertical height of 30 inches from bottom. The odd-numbered frames from 27 to 109, inclusive, and all frames in bow wings and stern rake are of 3 in. × 2½ in. × 5.5 lb. angle bars. All floor frames are to butt on the center line of hull and will be connected by splice plates and angles at least 18 inches long. The bulkheads take the place of the frames for which they are numbered.

55. Deck beams.—From frame No. 24 to No. 126, inclusive, the even-numbered deck beams are of 6 in. × 15.6 lb. Z bars, and the alternate beams are of 3 in. × 2½ in. × 5.5 lb. angle bars; the short beams at bow wings being also of 3 in. × 2½ in. × 12.8 angle bars. Deck beams No. 22, crossing end of well, and No. 128, at transom, are of 4 in. × 4 in. × 12.8 lb. angles. Each deck beam is attached to its corresponding frame by gussets, those for Z bars being 21 in. × 36 in. × ¼ in., and those for angle bars being 12 in. × 12 in. × $\frac{3}{16}$ in.

56. Transverse bulkheads.—The collision bulkheads are on frame No. 10 and the transverse bulkheads are on frames Nos. 32, 46, 62, 78, 90, and 110, respectively. They are all to be water-tight and are made of 7.65 lb. plate riveted to floor and deck beams and stiffened by 2 in. × 2 in. × 3.2 lb. angle bars placed alternately on opposite sides of bulkheads at a distance of about 24 inches apart. The joint of plates are to be double riveted lap. The collision bulkheads are to have manholes strengthened by an iron ring and provided with a water-tight door and also a 2½-inch gate valve for draining the compartments.

57. Longitudinal truss framing.—The side plating of well will be continued to bulkhead No. 32 and the inboard truss frames will then commence and run aft to transom, maintaining the line of well sides until they meet bulkhead No. 46, at which point they are 5½ feet each side of center line, and are continued parallel throughout the remainder of their length. The outboard trusses will run from bulkhead No. 32 to transom at a distance of 14 feet from center line. The top and bottom chords are to be made of two 2½ in. × 2½ in. × 5 lb. angles and 10.2 lb. web plates 10 inches wide, riveted to each 8-inch floor and all deck beams, and in addition by clips of 2½ in. × 2½ in. × 5 lb. angles, and such other suitable sizes as are required. The chords will pass through the transverse bulkheads intact and be made water-tight by the angle connections. Lattice bracing in double panels made of 2½ in. × 2½ in. × 5 lb. angles will be worked in between transverse bulkheads, as shown on sheet 6. The after ends of trusses will be attached to transom by double angles 2½ in. × 2½ in. × 5 lb.

58. Gunwales.—The gunwales are to be of 3 in. × 3 in. × 7.2 lb. angle, to be riveted on outside of sheer strake, and will extend continuously from bow to stern.

59. Hull plating.—The bottom of hull will be plated with 10.2 lb. plate except keel strake and rake of bow wings, which will be of 12.75 lb. plates; the bilge strake or knuckle will be of 12.75 lb. plate throughout; the sheer strake will be 12.75 lb. between frames Nos. 20 and 116, and 10.2 lb. at the ends; the side plating of hull and well will be 10.2 lb.; the end of well will be 20.4 lb. in one plate, and the rake of well 12.75 lb. plate. The seams of keel strake will be double riveted and all other seams will be single riveted, and all butts will be double riveted. The bottom plating will be in 13 strakes laid alternately inside and outside, the keel strake being on the outside. The width of bottom strakes will be 36 inches center to center of laps and the ruling length of plates will be 18 feet. All butts will be planed and fitted close, metal to metal. Butt straps must be $\frac{1}{16}$ inch thicker than the plates which they connect and must be fitted close between the edges of inside strakes. Solid liners in one length must be fitted at every frame between frame and outside strake of plating. The liners must be the full width of the flange of frame to which they are fitted except in the way of water-tight bulkheads, where they will

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extend in one piece from the fore edge of the frame before to the after edge of the frame abaft the bulkhead.

60. Deck plating.—To be in 15 strakes, each 36 inches wide center to center of laps, except the plate sheer, which must be of the requisite width to project 2½ inches outside of gunwale angle, except between the wheel beams, where it will be flush. The plate sheer will be of 12.75-lb. plate for the length amidship between frames Nos. 34 and 112, and all the remainder of deck will be of 10.2-lb. plate. The deck will be level throughout, without sheer or crown, and will be laid alternately inside and outside strakes; and all seams, butts, butt straps, and liners will be similar to those specified above for the hull plating, the center strake being an outside strake.

61. Riveting, etc.—Rivets are to be of soft steel or Burden's best, and ⅞ inch in diameter throughout the hull, except where otherwise specified or noted on drawings or the nature of the work requires a different size. The rivets in seams and butts of outside plating will be spaced not more than 2½ inches apart center to center, and rivets in seams of all internal water-tight work will be spaced not more than 2¾ inches centers. All double riveting will be chain fashion, except where otherwise noted on drawings. The distance from center to center between the rows will be 1¾ inches. No rivet will be nearer the seam, butt, or edge of plate or angle bar than its diameter. Spacing of rivets in beam knees will be from 2¾ to 3½ inches centers, but no beam knee will be secured to its frame with less than four (4) rivets. Rivets for securing outside plating to floors and frames, stiffening angle bars to bulkheads, and for all work where angle bars do not require to be caulked will be spaced not more than 5 inches centers. Heavy drifting must not be resorted to, and holes not punched fair must be reamed fair and a size of rivet to fit the hole must be used. Countersinks must be not less in depth than three-fourths the thickness of the plate or angle bar countersunk. Rivets will completely fill their holes, the heads will be laid up in all water-tight work, and the points of rivets when finished will completely fill the countersinks and be flush or slightly convex with the surface of plates.

62. Guards.—The guards will extend the full length of hull, of the form and dimensions shown on sheet 2. The wheel beams are to be opposite to bulkheads Nos. 62 and 78 and are to be 24 feet apart center to center, projecting 12½ feet from hull, with a landing of 28 inches on side plating. They will consist of 3-in. × 3-in. × 7.2-lb. angles doubled for top and bottom chords, with webs of 10.2-lb. plate, and will be further secured to deck by gusset plates, and the outer ends built into bridgetrees. The outriggers next to wheel beams will be of similar construction, but with single angle bars and 7.65-lb. plate. Diagonal braces of 5-in. × 2½-in. × 11-lb. T bar will be riveted to under plate sheer at ends of wheel beam and extend to hull, as shown on sheets 2 and 7, and riveted to all the outriggers they cross. Fore and aft from these the outriggers will be made with two chords of 2½-in. × 2½-in. × 5-lb. angle latticed together by bars of 2-in. × 2-in. × 3.2-lb. angles and gusset plates, and attached to nosing plate by 2½-inch angle clips. Towards the bow, where the guard narrows, the bottom chord can be omitted and gusset plates used. The outriggers will be spaced 36 inches apart and coincide with the even-numbered frames, and have a rise at the outer end of 6 inches at the widest part. The guards fore and aft of paddle boxes will be decked with 7.65-lb. plate, which will be riveted on the under side of plate sheer and to all the outriggers. Between each outrigger the deck will be stiffened by 2-in. × 2-in. × 3.2-lb. angle bars at intervals of about 36 inches. Scupper holes 1½-inch diameter will be made at intervals all along the guard at edge of deck plating.

63. Bridgetrees.—These will be box girders built on the ends of wheel beams, and will consist of top plate 18 inches wide by 12.75 lb., two web plates 8 inches deep by 12.75 lb., four angles 3 in. × 3 in. × 7.2 lb., and lattice bracing on bottom, as shown on sheet 7. On the center of bridgetree is built the bolster for outboard bearing of paddle shaft, the top chord angles to be 4 in. × 4 in. × 9.8 lb., which will be carried down and secured to bridgetree as braces. The height and size of bolsters may be modified to suit the requirements of engine builder.

64. Wheel beam chains.—The outer ends of wheel beams will be supported by 2-inch rods with 2½-inch upset ends, hung from posts made of 6-in. × 8-lb. latticed channel bars, with tie rods 1¾ in. diameter and 2-inch turn-buckles running from post to post close under stringers of boiler deck.

65. Guard chains.—The guards will be held at intervals by chains of similar design to the above, but rods will be 1½-in. diameter, with 1½-in. threads, and the posts will be made of two 4-in. channel bars riveted together through web, the tie rods being 1¼-inch diameter with 1¾-inch turn-buckles

66. Guard rim and nosing.—Along the outside of guard and attached to all the outriggers will be a plate 8 inches deep by 10.2 lb., the top and bottom edges stiffened by 3-in. × 3-in. × 6.1-lb. angles, the upper one riveted to deck of guard and the lower one to under plate sheer, which will be 12 inches wide by 10.2 lb. The nosing will be of white oak 6 in. × 8 in., rebated to fit angle on top and secured to plate with ¾-inch bolts placed 18 inches apart and staggered. Joints are to be

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scarfed 3 feet long, and everywhere where the oak comes in contact with metal a thickness of tarred felt must be inserted. All edges of nosing are to be properly rounded and finished in a neat and workmanlike manner.

67. Transom.—This will be of 12.75-lb. plate 24 inches deep, with stiffening plates for rudder bearings.

68. Stanchions and stringers.—Stringers of 3-in. × 2½-in. × 5.5-lb. angles are to run from bulkhead No. 32 to collision bulkhead No. 10 and have stanchions of 3 in. × 3 in. × 6.1 lb. riveted in with small gussets at 36 inches apart. Any other stanchions that may be needed under boilers or any machinery not sufficiently carried by bulkheads or truss frames must be supplied and riveted to deck beams and floors in an efficient manner.

69. Additional trusses.—The heavy pumping machinery will require additional truss framing between deck and floor, which must be put in, also any other trussing that may be needed for any of the other heavy machinery.

70. Foundations for boilers.—The requisite beams under the ash pans and cradles for mud drums will be provided and riveted to deck.

71. Foundations for machinery.—That part of deck upon which the main engines and pump are placed will be reinforced with 15.3-lb. plate, the spaces between the deck strakes being filled both inside and outside with plates fitted snugly between the edges of laps, thus making a total thickness of ½ inch. Under the air and jet pumps, filling plates are to be inserted where required, and all filling or doubling plates required for other purposes are to be provided.

72. Discharge pipes in hold.—These pipes will be 32 inches diameter inside and made of 10.2-lb. plate with flanges of 2½-in. × 2½-in. × 5.9-lb. angle bar riveted through and through with bulkheads and forming a part of the hull structure. Care must be taken to have the longitudinal seams placed on top of pipe with as short a crossing of joints as possible, and the circular seams laid in the direction of the flow. At all flanges throughout the main pump pipes the plate forming the pipe must come flush with flanges in order to prevent the sand from cutting the plate, and care must be taken in cutting holes in the bulkheads that when finished all the plates shall be quite flush with each other, as shown by section on sheet 6. The discharge pipe, where it passes through the rake of stern, must be made of 15.3-lb. plate for about 18 feet of its length, and must be connected to hull with flanged plates not less than ⅝-inch thick. To the outboard end of pipe the cast steel elbow hereinafter described will be riveted. All rivets in discharge pipes must be countersunk and driven flush on the inside. The bend of pipe from bulkhead No. 46 must be made of plate ⅝-inch thick in small segments. At the after end of pipe a hand-hole must be provided, fitted with a cover which can be quickly removed, for the purpose of filling or emptying the pipe by means of a syphon.

73. Bow girder.—A box girder will be built between the two wings at fore end of well, flush with nose of dredge, this girder to be 36 inches wide and 36 inches deep, the top standing 12 inches above deck, and is to be made of 10.2-lb. plate, with 3-in. × 3-in. × 7.2-lb. angles on three corners and 7-in. × 3½-in. × 19-lb. angle on the forward bottom corner; the girder will be strengthened by six transverse ties, spaced equally, and made of ⅜-in. gusset plates and 2½-in. × 2½-in. × 5-lb. angles. A second 7-in. × 3½-in. × 19-lb. angle bar will be riveted 18 inches above bottom, and both will be perforated with holes for screen bars at a distance of 8 inches center to center. The screen bars will be made of 3-inch extra heavy pipe 4 feet long, held in place by ¾-inch pins at top end. On the upper edge of girder a nosing of white oak 8 in. × 6 in. is secured, rebated, and bolted similarly to the side nosing. This girder is shown in detail on sheet 6.

77. Stack knees.—Four stack knees are to be built on the bow girder as shown on sheet 6. The front plates and knees are to be of 12.75-lb. plate and the angles 3 in. × 3 in. × 7.2 lb. The posts are to be of white oak, 9 in. × 9 in., mortised into nosing and bolted to knees, the fenders to be 7 in. × 11 in. at bottom and 5 in. × 11 in. at top, and must be made of best white oak or hickory, fitted with eyebolts, and properly lashed.

75. Cylinder beams.—These beams are to be built according to sheet 9, except in so far as they may require modification to meet the requirements of the particular engines accepted for the dredge. The webs are to be of 12.75-lb. plate, the top chords to be two 5-in. × 4-in. × 11-lb. angles, with a cover plate 10 inches wide × 15.3 lb., the bottom chords to be two 4-in. × 4-in. × 9.7-lb. angles riveted to deck. Stiffeners of 2½-in. × 2½-in. × 5-lb. angles will be placed about 36 inches apart, and gussets and tie plates as shown.

76. Hoisting frame.—This frame, from which the suction heads are to be suspended, will consist of two A frames set upon each side of well and joined together at the head by plates. Each leg is to be made of a pair of latticed channels 9 in. ×14 lb., tied together at the head by gusset plates and secured to deck by gussets and angles, as shown on sheet 12. The tackle blocks will be suspended from a pin in the head of frame.

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77. Spud well.—This is built near bow of dredge, between frames 24 and 26. It will be 23½ inches square in the clear on the inside, made of 12.75-lb. plates and 3-in. × 3-in. × 7.2-lb. angles. The bottom flange must be a steel casting, double riveted to hull plating. (See sheet 16.)

78. Bitts, chocks, and cavils.—The following number of these deck fittings are required, placed where shown on deck plan, sheet 2. They must all be set on stiffening plates riveted independently to deck plate and beams, and secured by riveting as far as possible. Four large cast-iron mooring bitts about 11 inches diameter and 24 inches high; twelve smaller bitts about 7 inches diameter and 16 inches high; six pairs of sheave chocks with sheaves about 9 in. × 3 in.; seven cavils about 4 feet; and such ringbolts as may be required for snatch blocks.

79. Fair leads.—Two pairs of fair leads with 24-inch sheaves for 1-inch diameter wire rope are to be made, as shown on sheet 6, and set in place on bow girder as on sheet 2.

80. Hatches.—Hatchways must be made in deck to give access to the several compartments of the hold, and be provided with iron covers made of 5.1-lb. plate, with 1½-inch angle rings and stiffeners on the under side and ring bolts for lifting. Iron ladders must be provided and placed in convenient position in each hatchway.

81. Rudder knees.—Two box knees, 4 feet high, made as shown in detail on sheet 6, are to be built at stern.

82. Rudders.—Two balanced rudders are required, each placed at a distance of 9 feet from the center line of boat. The rudder stocks are to be lap-welded tubes, 8 inches diameter and ⅝-inch thick and about 18 feet long, and will have three grooves turned in each at the distances required to receive the pintle bands. These bands are to be good sound forgings, and must be bored to fit the grooves snugly, sprung into place, and securely bolted. Near the upper end of stock, cheek pieces, either forgings or steel castings, must be riveted and have a 2½-inch pin hole bored through center to receive the tiller pin. At the end of stock a smaller hole is required for the tiller brace. The blades of rudder are to extend forward 12 feet, shaped to fit the rake of hull, and on the after end the blade is to be 12 feet long and 4½ feet wide. The blades are to be built of 7.65-lb. steel plates, and 2½-in. × 2½-in. × 5-lb. angle bars. Pieces of 7.65-lb. plate will be bent to fit the stock and will be flanged on both sides and riveted to both the fore and after faces of stocks. Secondary stiffening plates will be riveted on the athwartship center line of stocks, and will fit close to and extend beyond the above-flanged plates, both fore and aft. The plates of blades will be laid on these stiffeners and will be riveted thereto, then brought together at the fore and aft edges and riveted together with a 3-in. × ½-in. bar inserted between. The side plates will be stayed throughout by ⅝-inch through rivets, with pipe ferrules inserted between. The bottom will be closed with a ⅜-in. plate and outside angle bar 2½ in. × 2½ in. × 5 lb.; and finally, the top edge will be filled in with hard wood about three inches thick and riveted through and through. The rudders are not to be water-tight, and a number of ¾-inch holes will be punched in bottom plates. The pintle pin will be 1¼ inches diameter, and bronze washers will be inserted between all the lugs in order to insure a distribution of the weight of rudders on each bearing. Lifting shackles and bumpers will be provided.

83. Tillers.—Each tiller will be made of two (2) 4 in. × 1 in. bars riveted together with separators between, as shown on sheet 6, and will have eyes forged at one end to couple to rudder stocks, and a ring at the forward end for attaching tiller ropes. The two tillers will be connected by a brace of 3-inch tube with pin joints at each end, and the weight of outer end will be sustained by a brace of 1-inch iron, with upset thread, running to head of rudder stock. Any modification of the tiller ends that may be necessary to accommodate the steam steering rig will be made as required.

84. Sheer legs.—A pair of sheer legs will be set up at stern for lifting the swivel elbow and rubber hose connection. These are to be made of tubing with stub ends welded in, and will be stepped by pin joints in steel castings riveted to deck. Extra lugs are to be placed for setting up legs over rudder, and ring bolts or other fastenings to be provided for securing back guys and snatch blocks.

85. Material and workmanship.—The best quality of material and workmanship will be required in each and every part of the work done under these specifications. All plates and angles used in said work are to be of soft steel having an ultimate tensile strength of from 52,000 to 62,000 lbs. per square inch, the elastic limit not less than one-half the ultimate strength, with an elongation of 26 per centum in 8 inches and a minimum reduction of area at fracture of 50 per centum. One test piece for tensile strength and one for bending shall be taken from the steel of each heat. For the bending test, the pieces will be bent cold 180 degrees flat upon themselves without fracture on the outside of bent portion. A variation of more than 2½ per centum above or below the specified thickness will be cause for the rejection of any material. Rivets will be tested cold by driving the shank into the head; the rivet must then be without sign of fracture on the outside edge. Facilities must be given to

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the inspector by the manufacturer and contractor for making these tests, the cost of which will be borne by the contractor.

86. Testing of hull.—The bottom of hull will be tested for water-tightness by filling with water to a depth of about 6 inches, before the boat is launched, and all leaks and imperfections then discovered will be made good.

UPPER WORKS.

87. Deck house.—The forward end of deck house will be 16¼ feet from end of well and the house will extend aft to 16½ feet from stern; it will be 44 feet wide, but drawn in at the after end to conform with the shape of boat.

88. Material.—All lumber used in the construction of the upper works and in all other carpenter work must be first class, clear and well seasoned, free from sap wood and shakes, dressed on sides and edges, and of the sizes specified after being dressed.

89. Framing.—The main stanchions are to be of white oak 3½ in. × 3½ in., placed about 8 feet apart and secured by angle clips riveted on deck, as shown in detail on sheet 6. The intermediate stanchions are to be of 1¼ in. × 3 in. white pine, spaced about 24 inches apart and carried by sills of white pine 3 in. × 4 in. checked into main stanchions and supported in middle by iron knees riveted to deck.

90. Clamps.—The outside clamps are to be 1¼ in. × 10 in. white pine, and the inside clamp 1¼ in. × 6 in. white oak, checked into stanchions and bolted with ½-inch carriage bolts.

91. Carlins.—These are to be 1¼ in. × 6 in. yellow pine, spaced about 18 inches apart centers, curved to a crown of 6 inches and checked over inside clamp 1 inch deep. Each carlin will be in two pieces, overlapped or scarfed in center and projecting 6 inches beyond outside clamp. The carlins are to be doubled at bulkheads or where extra strength is required.

92. Stringers.—These are to be of yellow pine 4 in. × 6 in., in long lengths, with scarfs 3 feet long, bolted and nailed and secured to caps of stanchions by ½-inch screw bolts.

93. Stanchions and trusses.—All stanchions for stringers are to be made of 3½-inch diameter iron pipe secured to deck and stringers by cast-iron flanges and distributed as shown on sheet 2. Where the span between the stanchions is over 10 feet, the boiler deck is to be supported by trusses.

94. Boiler deck.—This will be laid with white pine ¾ inch thick, in strakes 3 inches wide, tongued and grooved, and beaded on under side. The height of boiler deck from main deck will be 12 feet. The guards will overhang the deck house 6 inches and will be finished with a waterway 3½ in. × 1¼ in., facing 8 in. × ¾ in., nosing 6 in. × ¾ in., all of white pine. The boiler deck is to be doubled over the whole of intermediate section of cabin between the two passages with white pine ¾ in. thick, in strakes 3 inches wide, slightly outgauged, caulked with cotton, and payed with thick white lead.

95. Siding.—The deck house will be sided with white pine ¾ inch thick, tongued and grooved, and beaded on both sides, in strakes 3 inches wide laid longitudinally, except at round corners, which will be vertical. A row of transom sash will be placed below clamps, and all doors, windows, and shutters will be put in as required.

96. Bunker.—This will be built of the size and in the position shown on sheet 2. It will be made substantially in the same manner as the side bulkheads, sided on the outside of studding clear up to carlins, and on the inside to a height of 6 feet with 1½-inch yellow pine, tongued and grooved.

97. Stairs.—There will be two flights of stairs on each side of boat from guards to boiler deck. They will be 30 inches wide, with oak treads 9 in. × 1⅛ in., with about 7½-inch rise. Two sets of steps from boiler deck guards to top of paddle boxes, two sets from paddle boxes to hurricane deck, and 6 sets to skylight roof are to be provided.

98. Lockers.—Such lockers as are usual and requisite for engine room and ship stores, lamp room, and mate's lockers are to be provided as shown.

99. Lavatory, etc.—Three closets located abaft the paddle box on port side and a crew's wash room in a similar position on starboard side are to be provided and fitted out as hereafter described.

100. Paddle boxes.—These are to be made as shown on sheet 8, with a framing of 2½ in. × 2½ in. × 5-lb. angle bars, upon which nailing strips of poplar 2½ in. × 1½ in. are to be bolted with ½-inch carriage bolts. Coamings of white oak 5 in. × 2 in. are to be bolted to bridgetrees with a strip of tarred felt interposed, upon which the stanchions are stepped. These are to be of white pine or poplar 3 in. × 1½ in., spaced 18 inches apart centers, and secured at top end to angle framing. The whole is to be sided with white pine ¾ in. thick, in strakes 3 inches wide, tongued and grooved, and beaded on outside. The outboard face is to be neatly finished with facing of white pine 6 in. × 1½ in., panel of poplar 12 in. × $\frac{5}{16}$ in. thick, and a 2-in. half-round molding rebated over panel. The center piece of lattice work is to

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be removable and the star is to be made of $\frac{5}{16}$-in. panel and 1¼-in. half-round molding. The bulkhead of deck house will form the inboard siding, but it will be doubled by ½ in. white pine siding, tongued and grooved, with vertical nailing strips 1½ in. × 1½ in. between. Both bulkhead and doubling must be painted with three coats of pure white lead paint before being closed in. A flight of steps 24 inches wide is to be placed on each side of paddle boxes.

CABINS.

101. General.—The general arrangement of cabins is shown on sheet 3. The total length will be 137 feet and the width 34 feet. The forward cabin will contain 13 staterooms, bathroom, and storeroom, all 10 feet wide, with office and mess room 14 feet wide between. The intermediate section will contain kitchen, pantry, three storerooms, laundry, laundress' room, wash and bath rooms, and closets for officers. The after section will contain quarters for cook and waiters, ice box and storeroom open to passage, crew's mess room, crew's quarters, and two bathrooms. There will be two passages 5 feet wide between the sections. The skylight will extend full length of cabin, at a width of 14 feet.

102. Dimensions and material.—The cabin outside stanchions are to be of poplar, 1 in. × 3½ in.; the inside stanchions of poplar, 1½ in. × 3 in.; the plank sheer of white pine, ½ in. × 3½ in.; the outside clamps of white pine, 1½ in. × 7 in.; the inside clamps 1½ in. × 5 in.; the carlins of poplar, 1 in. × 4 in.; the bulkhead strips of poplar, 1 in. × 1½ in.; the panels of poplar, $\frac{5}{16}$ in.; the margins of white pine, ½ in.; the roof facing and nosing of white pine, ½ in. × 4 in.; the waterway of white pine, ½ in. × 2 in. The skylight clamp is to be of white pine, 1½ in. × 8 in.; carlins of poplar, 1½ in. × 5 in.; facing of white pine, ½ in. × 4 in.; nosing of white pine, ½ in. × 3 in.; waterway of white pine, ½ in. × 1½ in.

103. Construction.—The cabin and skylight roofs are to be ½-in. white pine, tongued and grooved, beaded on under side, and double nailed to each carlin. The height of cabin from carlin to carlin will be 8 feet, and the general construction will follow the ordinary river practice. The cabin ceiling will be paneled with an OG molding; the skylight carlins will be capped on under side; a plain cornice will extend the full length of the skylight, and the forward cabin will be finished with pilasters on each side of doors and plain brackets to cornice. All rooms will have transom sash on the outside, and those in forward cabin will have transoms inside also. The intention is to have all the joiner work done in a thoroughly good and substantial manner and neatly but plainly finished. The cabin will have four (4) ⅝-inch bolts on each side, passing from carlins to under side of boiler-deck carlins.

104. Pilot house.—This will be 13 feet long fore and aft, 13 feet wide, and 10 feet high from skylight roof to under side of carlins. The floor beams will be 1½ in. × 10 in., spaced about 18 inches centers, carried on rails 1½ in. × 6 in. on each side of house. The floor is to be of ½-inch yellow pine, tongued and grooved. The corner stanchions will be 3 in. × 3 in., and the siding is to be of white pine ⅝-in. thick, tongued and grooved, and beaded on both sides. The pilot house will be fitted with the usual adjustable sight shades in front and with sliding shades on the other three sides. The sashes will be 1⅜ inches thick and mounted with rollers on brass water tables. A door 30 inches wide will be provided in afterside of pilot house, with suitable steps to same. The pilot house will be securely fastened down by a ⅝-inch bolt at each corner stanchion.

105. Pilot wheel.—This will be 10 feet in diameter over all, with double rim of usual construction and mounted in the usual manner. The barrel will be 15 inches in diameter, and the necessary tiller ropes, ½ inch in diameter, with all sheaves and sheave boxes, will be provided and fitted in place in a first-class manner. The fittings in pilot house will include speaking tube to engine room, bell tube, bell stand, all necessary bell pulls and bell cranks, and wiring to engine room and whistle; also a settee with drawers underneath.

106. Roofs.—All roofs will be covered with 12 oz. cotton duck, U. S. Army standard, of approved make, well lapped at edges and secured with 10 oz. copper tacks, laid on a thickness of heavy roofing felt and painted with two (2) coats of pure white lead, ground in boiled linseed oil and toned to lead color with lamp black. The boiler deck guards for the full length of cabin and the passageways must also be covered with canvas and painted same as the roof.

107. Guard rail.—This will extend all around the boiler deck. It will be made with stanchions of white oak, 1½ in. × 1½ in., spaced about 6 feet apart centers, with one short stanchion of white pine between. The rail will be 29 inches high. The caps are to be of white pine, ½ in. × 4 in., with filling on each side of stanchions ½ in. × 2 in., and two rails of white pine ½ in. × 2 in.

108. Doors.—All doors are to be made of white pine; those 27 inches wide and under to be 1 inch thick and those above 27 inches wide to be 1½ inches thick. Inside doors will be paneled and outside doors will have the lower part paneled and the

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upper part glazed. All state room outside doors will be fitted with blinds of white pine ⅞ inch thick. The doors will be hung with steel loose pin butt hinges and fitted with rim locks and white porcelain knobs of extra good quality, and all necessary brass hooks and eyes of ship cabin pattern. The blinds to outside doors will have 2½-inch brass shutter bars with brass hooks and eyes for fastening back. The sliding doors on main deck will be mounted with "Run Easy" warehouse hangers with 6-inch wheels and 1¼ in. × ⅛ in. rails, and will be fitted with flush door handles and suitable locks.

109. Windows and transoms.—The windows will be single sash, 1¼ inches thick, and transom and skylight sash will be 1 inch thick. The windows will be made to drop on inside of bulkheads and will be fitted with slides and water tables, sash weights, pulleys, cords, and fastenings. The transom sash will be hung at top, the skylight sash at bottom, and all will be provided with the necessary buttons, chains, hooks, and spring bolts. All glass used is to be double strength "American," and sashes must in all cases be made to use lights of standard size. All hardware furnishings must be approved by the engineer officer in charge.

110. Forward cabin and state rooms.—Each of the eight state rooms in after part of cabin will be fitted with a locker 36 inches wide and 21 inches deep, with two (2) drawers below and paneled doors in two parts above, and provided with drawer pulls, cabinet locks, hinges, spring catches, and six (6) heavy clothes hooks to each locker. The floors of office, officers' mess, and all state rooms in forward cabin, also floor of pilot house, will be covered with linoleum. Iron bedsteads will be furnished throughout the boat, as hereafter specified.

111. Kitchen, pantry, etc.—The kitchen will be fitted with fixed tables, placed as shown on plan, and the pantry will have a wash table, four (4) tiers of shelves, and drawers. Store rooms will also be fitted with shelving in a complete manner, a baker's table as shown, and the doors will be fitted with first-class locks.

112. Laundry.—The laundry will be furnished with an ironing table 24 in. × 36 in. on top, made of white pine, and the laundress' room will have linen lockers, with shelves and double doors.

113. Crew's mess room.—This will be furnished with two plain tables, 3 ft. × 11 ft., made with pine frames and hard-wood tops; also four seats 11 feet long to suit same.

114. Ice box.—An ice box of first-class construction, charcoal filled, will be placed in after passage and fitted with drain pipes.

DREDGING MACHINERY.

115. Main pump.—This is to be a 32-inch centrifugal double suction pump, with discharge at bottom, and will be placed on the center line of boat, as shown on sheet 2. The pump runner is to be made with five blades, 75 inches diameter, keyed upon a hammered steel shaft with two keys driven from opposite sides. The pump casing must be divided horizontally through the axis of the shaft, and the top half must be divided again vertically, and all be put together with planed joints. The casing must not be less than 2 inches thick anywhere, and must be 3½ inches thick at throat, gradually diminishing to 2 inches. The suction elbows are to be 24 inches diameter, increasing towards the casing to 27 inches, and must be made in halves and set at an angle of 45 degrees, as shown, provided with stuffing boxes lined with brass sleeves, and fitted with brass glands and sand intercepting chambers to which water-jet connection will be made. All fittings which go on shaft must be in halves, with faced joints, and must be put together in a first-class manner. A flange, well bracketed, must run all around lower half of casing for securing pump to deck, and lugs or eye bolts and shackles must be provided for lifting the various parts. The pump is to be provided with a 4-inch air exhauster, with pipes arranged as shown on sheet 4, having flange connections for easy removal. The casing and elbows will have handholes for examining the inside of pump, the covers in all cases to be as close a fit as possible and flush on the inside. The blades of pump runners are to be made without wearing plates and not less than 1¼ inches thick.

116. Pump shaft.—This is to be of hammered steel, 9¼ inches diameter in center and 8¼ inches at ends, and about 11½ feet long. A flange coupling of cast steel will be keyed on each end.

117. Main engines.—These are to be horizontal tandem compound condensing, with high-pressure cylinder 16 inches diameter, low-pressure cylinder 26 inches diameter and 20 inches stroke. They must be designed for heavy and continuous service, with double cranks, oil-bath lubrication, and automatic shaft governors, and should not exceed the space allotted to them on the plan. The crank shafts are to have flange couplings on one end, worked solid with the shaft, to match those on pump shaft. The cylinders are to be provided with automatic drain cocks, relief valves, sight feed, and other lubricators, and a small separator for each engine; also indicator cocks on each cylinder, and rig for taking diagrams. The holding down of engines will be by continuous flange all around base and frequent bolts of small

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size. The engines will be run continuously at a working speed of 160 revolutions per minute, but must be perfectly balanced for running a test speed of 175 revolutions per minute.

118. Throttle valve, etc.—A balanced regulator or throttle valve is to be provided, with a convenient arrangement of handle for working same placed between the engines. The steam pipes are to branch from each side of valve to cylinder by easy curves, and a small separator is to be directly connected to each cylinder, the drain from which must be taken off by a steam trap.

119. Condenser and air pump.—The condenser is to be of the independent type, and the air pump is to be duplex compound, with steam cylinders 10 and 17 inches diameter, water cylinders 19 inches diameter, and 15 inches stroke. The water cylinders are to be brass lined, and the pistons fitted with suitable packing. The pump will discharge into a hot well placed in the hold of dredge and fitted with a steam-tight cover, and the injection will be taken from a tank fitted with brass wire screen and shut-off valve on inlet.

120. Jet pump.—This pump for supplying the water to nozzles of jet agitator is to be horizontal duplex compound, with outside packed plungers. The steam cylinders are to be 10 and 20 inches diameter, and the plungers 16 inches diameter by 15 inches stroke. The steam pipes are to be arranged so that live steam can be used in low-pressure cylinder, and all parts must be made of sufficient strength for this purpose. This pump will be required to work against varying pressures, from about 60 lb. when working compound to 120 lb. when working the large cylinder high pressure. A modification of the ratios of cylinders will be allowed if desired. The pump plungers must be made as light as consistent with the required strength, and must be of hard, close-grained iron, and the glands and stuffing boxes must be bushed with bronze. The valves must have ample area and the passages be large and direct. The cylinders are to be made of hard, close-grained iron of sufficient thickness to admit of reboring, and the pistons will be fitted with approved adjustable packing rings. The cylinder heads must be so arranged that the pistons can be removed without taking down any other part of machinery. The suction will be taken from a tank placed in hold of dredge, which must be fitted with brass wire screens and the inlets provided with shut-off valves close to hull plating.

121. Suction heads.—These are to be made as shown on sheet 10. Each mouthpiece is to be 11 feet 6 inches wide and 8½ inches deep at its smallest part, and have a flared entrance, the upper edge being strengthened by a 3 in. × 3 in × 7.2 lb. angle bar and the lower edge by a 4 in. × 13.8 lb. Z bar or double angle riveted together. The heads will gradually contract until they are 22 inches square inside, at which size they are continued to the bow and enter the hull by means of radial joints. The heads are to be built of steel plates 12.75 lb. on top and sides and 15.3 lb. on bottom, with 3 in. × 3 in. × 7.2 lb. angle bars in corners. All joints are to be closely butted with straps outside, and all rivets to be countersunk on the inside and made flush. A double angle bar 4 in. × 3 in. × 8.5 lb. is to be riveted on each side of center line on top side, with a plate between to which the sling chains are to be connected by shackles. Diagonal tension rods and a coupling bar will be fitted between the two suction heads as shown. The entrance of mouthpieces will be fitted with screen bars of cast steel, placed at 8 inches centers, held in place by a bar of 1½-inch pipe secured at each end. Stiffening bars of 2½ in. × 2½ in. × 5 lb. angles are to be riveted to upper lip of mouthpieces.

122. Radial joints.—These are to be made as shown on sheet 11. Both hing pieces are to be steel castings, all flanges to be faced and pin holes bored an easy fit for 3½-inch pins. The pipe pieces are to be riveted to suction pipes, and the plates and angles to come flush with face. The radial pipe is to be of cast iron and to be machined all over to a smooth surface. The inside pipes are to be of cast iron, faced on flange and bolted independently to the bow hinge pieces. These pieces will change from square to round and be connected to the suction pipes of pump by short pieces of 8-ply rubber hose, made in the same manner as described for pipe-line connections, paragraph 135.

123. Water jets and pipes.—A header of 8-inch standard pipe will be placed behind Z bars on under side of suction head, perforated with 12 holes tapped for 2-inch pipe, into which bronze nozzles with 1-inch outlets are to be screwed, the ends of nozzles to rest in holes made in center of Z bars. The 8-inch pipes will be continued from a tee in center of header along the under side of suction heads to near the upper end, where connection will be made to branch on hull by sections of smoothbore suction hose, which must be of sufficient strength to stand a pressure of at least 180 lb. per square inch.

124. Hoisting tackle.—The suction heads will be suspended and hoisted by wire rope tackle hung from frame at bow of dredge. It will consist of two pairs of 30-inch sheaves grooved for ½-inch rope and bushed with best bronze for 3½-inch diameter pins, with all the necessary sheave frames, straps, shackles, etc., which must be forged in the best possible manner. The connection to suction heads is to be made of a double-legged sling of 1½-inch chain.

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125. Hoisting winch.—One winch for hoisting suction heads is to be made substantially as shown on sheet 15. Engines are to have 7 in. × 7 in. cylinders geared about 32 to 1, with drums 42 inches diameter grooved for ¾-inch wire rope, and fitted with brake and all handles required for operating. All pinions are to be of steel.

126. Hauling ahead winches.—Two winches are required, which must be fitted up for right and left hand, and made substantially as shown on sheet 14. The engines are to have 7 in. × 7 in. cylinders, geared about 412 to 1. The drums are to be 48 inches diameter, grooved for 1-inch wire rope, and fitted with all clutches, brakes, levers, etc., required for operating. All the pinions are to be of steel and the worms of bronze. All the winches are to be neatly finished in all parts, the cylinders lagged with planished steel, 16 B. W. G., the bottom flanges to be planed and ample holding-down bolts provided.

127. Spud anchor and lifting gear.—The spud anchor is to be of best white oak, 22 inches square and 36 feet long over all, fitted with a cast-iron shoe at lower end. The lifting cylinder is to be 18 inches diameter with a stroke of 6 feet, and fitted with a steel piston rod 4 inches diameter; the piston to have approved packing rings; the gripping cam to be of steel; the links of forged steel or iron, and the racks of steel. The tripping dog is to be forged of steel or iron and fitted up in the best manner. A back roller is to be provided with bearings for same, and also a 2-inch rotary valve and all working handles.

128. Capstans.—Three double-barreled steam-power capstans are required, two for forward deck and one for stern. The engines are to have cylinders 7 in. × 8 in. All the gears are to be of steel and the worms of bronze. The engines will be placed in hold, the forward ones on foundation plates riveted to floor beams and the after ones on under side of deck. They are to be "Providence" capstans or others of equal quality approved by the engineer officer in charge.

129. Steam steering rig.—This is to be direct acting and of a design approved by the engineer officer in charge, and must be as simple as possible, easily handled, must not interfere with the use of the pilot wheel, must be quickly disconnected, and must be first class in every respect.

130. Bilge siphons.—A 2½-inch bilge siphon is to be placed in each water-tight compartment, fitted with all necessary valves, piping, and suction screens. As the lift of the water is only about 5½ feet, the size of steam pipes is to be made in proportion. The height of discharge above water is to be not less than 18 inches, and those siphons discharging aft of wheels are to have elbows on outside to prevent wash of wheels being taken inboard. A 2½-inch siphon is to be located at the stern of boat and connected with two pieces of smoothbore hose so that discharge main can be filled or pumped out as required.

131. Pipes through hull.—All pipes discharging through hull are to be connected by tight joints to skin plate; all above 1½ inches, by flanges and bolts; and the smaller pipes, below 1½ inches, by lock nuts. Steam traps must be supplied where required to prevent steam from being blown about the boat, and all pipes discharging under pressure are to have elbows on the outside.

132. Swivel elbow for discharge.—This swivel will consist of two elbows 32 inches inside diameter, coupled together by collar flange working in a recess and held in place by a ring and bolts. The elbows are to be steel castings and the flanges and ring to be truly turned and bored to a working fit and have a bronze friction ring inserted between the faces. The lower elbow is to be riveted to the end of the discharge pipe projecting through stern of dredge and the upper elbow to have a bead on outer end on which the rubber-hose connection is to be clamped. Both upper and lower parts are to be braced with rods fitting into jaw brackets of steel, riveted to hull, as shown on sheet 13. The gudgeon for pivot brace is to be turned and the eye of brace to be bushed with bronze. The side gudgeons for coupling bars are also to be turned. Two forged eye bars, backed with 5-inch T bars, are to be supplied for coupling the pipe line to dredge.

133. Pipe line.—This will be 32 inches diameter and made in 10 lengths of 50 feet each. The pipes will be made of steel plate ¼ inch thick with lap joints, except at the end to which the hose is coupled, which must be butt-jointed and flush outside for a length of 12 inches, the end being finished with a bead of 1 in. × ¼ in. half-oval iron. The other end of each length is to have a flange of cast steel riveted on, truly faced so that pipes may be coupled together in 100-feet lengths and joints made without gaskets. Four experimental flanges are to be supplied, made as shown on sheet 13. The longitudinal seams are to be placed on top with joints crossed about 12 inches. The carriage frames and pivot caps are to made and secured to pipes as shown on sheet 17, and also suitable coupling bars for connecting the 100-feet lengths of pipe together. Each length of pipe is to be carried on a ponton 30 feet long, 13 feet wide, and 3½ feet deep, with 1 inch of crown on deck. The pontons are to be made of $\frac{3}{16}$-inch steel plate with 2½ in. × 2½ in. × 4.1 lb. angle-bar framing, and braced to carry the weight of deck load. The pipes will be centered on cast-steel pivots riveted in center of pontons, and the weight carried by carriages which are secured to pipes by strap bolts and which run on turntables of 3 in. × 1-in. bar

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iron riveted to deck of ponton by angle clips. Each ponton will have a tail fin hung from stern and braced to deck by ⅝-inch wire-rope guys and turnbuckles, and a rudder hung from the end of fin which will be worked from ponton by tiller lines. Each ponton is to have two locking chains, with turnbuckles for securing pipes to pontons in a fore and aft direction for towing, four small cavils of cast steel, and a small cast-iron snubbing post at nose, all riveted to deck. A locking clamp is to be attached to carriage to hold the ponton in any other desired position with relation to the pipes.

134. Baffle plate.—A swinging baffle plate is to be attached to the last length of the pipe line, made as shown on sheet 13, and operated from ponton by wire-rope lines and small capstan.

135. Rubber connections.—These are to be of 8-ply best Para rubber, with the inside lining of pure rubber ¼ inch thick, the ends also being capped with rubber to entirely protect the canvas from exposure. One length of 6 feet and four lengths of 3 feet are to be supplied, of suitable diameter to fit the pipes.

136. Hydraulic piles.—The dredge is to be supplied with twenty piles, 11 inches outside diameter and 35 feet long, made in two sections; the lower, 20 feet long, of tube ½ inch thick, and the upper, 15 feet long, of tube ⅜ inch thick, joined together by cast-steel flanges shrunk or pressed on and riveted. The flanges must be bored accurately to gauge and truly faced so that joint can be made without a gasket. The cap is to be a steel casting and made water-tight, and the upper tube is to have a hole drilled and threaded for 2½-inch pipe.

137. Wire ropes.—The following steel wire ropes are to be supplied, all of "Hercules" brand or other of equal quality: Two lengths, each of 1,200 feet, of 1-inch diameter hoisting rope, 19 wires to the strand, for bow lines; one length of ¾-inch diameter hoisting rope, 19 wires to the strand, for hoisting suction frames. These ropes do not require to be of a high tensile strength, but must be tough and pliable.

138. Electric light plant.—This installation is to consist of a direct-coupled vertical engine and generator of the multipolar type, of 110 volts, and the necessary capacity for operating the number of lamps specified below, with a margin of 20 per centum overload without undue heating. A slate switchboard is to be placed in a convenient position in engine room, mounted with ammeter, voltmeter, rheostat, pilot lights, and main switches for three circuits, one for main deck, one for cabin deck, and one for arc and search lights. Two search lights, each of 4,000 c. p., with 18-inch reflectors, are to be provided, arranged with both revolving and deflecting movements, the forward one to be operated from both the pilot house and the operator's platform, and the other from main deck. Two arc lights of 1,200 c. p. each are to be placed at each end of boat, arranged to give light to forward and after decks and to the main guards. The lights will be carried by spars, which must be properly rigged with guys and tackle for raising and lowering lights. The cabin deck will be lighted with 59 incandescent lights, distributed as follows: One combination electrolier for three lights and 3 coal-oil lamps, in office; three combination electroliers for two lights and two coal-oil lamps, two in officers' mess and one in kitchen; three portable lights for desk use in office and mess room; twenty-three bracket lights in state rooms, bath rooms, and closets; eight short pendant lights on guards, and sixteen hanging lights for storerooms, crew's mess room, crew's quarters, etc. The main deck will be lighted by about 36 lights distributed as shown on plan; these will be principally hung from wires and some will be portable and have wire guards. The hold is to be served with four lights, with long wires and wire guards to lights. All sockets are to be of the Edison pattern, and such as can be easily reached from the deck are to be key sockets, and all others are to have switches at convenient places for use. The lamps in cabins are to have suitable shades and all fixtures are to be very plain, but stronger than the ordinary commercial ones and put up in a thoroughly substantial manner. Two 32 c. p. lamps are to be furnished for chimney signal lights, with proper colored globes and suitably mounted in place, the switch to be located as required. All wiring in cabins and state rooms is to be concealed in neat mouldings, which are to receive one coat of white lead paint before being put in. All wires passing through bulkheads are to be enclosed in porcelain tubing; all insulators are to be of porcelain and the wiring and fittings generally to be in accordance with the rules and requirements of the National Board of Fire Underwriters.

PROPELLING MACHINERY.

139. Designs for engines.—Bidders are required to submit designs and specifications for propelling engines, subject to the conditions herein specified, as it is intended that contractors may use existing patterns if desired. Any slight modification of the cylinder beams that may be desired by the contractor will be allowed if it does not interfere with any of the other work on the boat.

140. Engines.—The engines are to be of the usual Mississippi River type, adapted for side wheels, and must be built of ample strength for working under a steam

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pressure of 170 lbs. per square inch. Special attention must, however, be given to reducing weights as much as possible consistent with strength required. The engines must be of simple design and have large wearing surfaces, balanced valves and variable cut-offs, both of types approved by the engineer officer in charge, and must have such modern improvements as are applicable to the design. They must be well fitted and neatly finished throughout, though a large amount of bright work will not be required.

141. Cylinders.—These will be of 22 inches diameter and 6 feet stroke, sufficiently thick to permit of two or three reborings, cast in dry sand molds of hard, close-grained iron, very smoothly bored, counter-bored ¼ inch at each end short of the travel of the piston packing rings, and must be entirely free from blow holes and spongy places. They must be first class in every respect, and will be fitted with the usual side pipes, valve boxes, valves and gear, also automatic drain cocks; and will be covered with approved magnesia nonconductor and lagged with planished sheet steel about No. 14 gauge. The cylinders will be fastened to beams without cast-iron bed plates, keying lugs only being used.

142. Piston rods.—These are to be hammered steel. The piston heads and followers are to be steel castings, with cast iron bull and packing rings. The rod will be fitted into piston against a shoulder, and into the cross head butt against the end, with only sufficient taper to enable cross head to be removed without driving. A backing cutter will be fitted to rod. Metallic packing of make approved by the engineer officer in charge will be used in stuffing boxes for piston rods.

143. Cross heads.—These are to be preferably of steel castings, and will be fitted with bronze gibs in the usual manner.

144. Slides.—These are to be fine, close-grained cast iron, truly finished, and will be fitted directly to cylinder beams without cast-iron bed plates.

145. Pitmans.—These will be about 28 feet long centers, and are to be built of iron or steel lap-welded tube, with solid stub ends inserted and efficiently trussed. They will be fitted with brasses lined with best babbitt metal, and gibs and keys.

146. Shafts and cranks.—These are to be of hammered steel, well designed, and will be fitted up in accordance with modern practice. Three wheel flanges hooped with wrought-iron bands will be firmly keyed on each shaft.

147. Pillow blocks, etc.—The pillow blocks, yokes, cams and cam brackets, and all other details, will be designed and fitted in accordance with best practice.

148. Throttle valves.—Each engine is to be fitted with a balanced throttle valve, placed conveniently within reach of the engineer.

149. Operating gear.—Each engine will be handled from its own side of boat; all levers must be arranged to occupy as little of the available gangway as possible. A steam reversing cylinder must be provided, the ship-up rig neatly and conveniently arranged, and the reversing shafts put under deck if necessary to make a suitable arrangement.

150. Bells.—Each engine must be supplied with signal bells of different and distinct tones, and all bells necessary for the proper working of the boat, together with fittings and wiring of first-class character, must be provided.

151. Paddle wheels.—The wheels will be 21 feet diameter over buckets and 22 feet over ends of arms, and each wheel will have three sets of arms, 15 arms to a set. The buckets will be 1½ inches thick, 10½ feet long, and different widths, as required to balance the varying strains upon the crank. The arms will be 7 inches at flange, 12 inches at circle, by 3 inches thick; the circle segments to be 7 inches wide, set up with keys, and secured with iron rings on each side 5 inches wide and $\frac{5}{16}$ inch thick, bolted with four ⅝-inch bolts to each segment. Three sets of braces are to be fitted between flanges and circles. Battens are to be 7 inches wide and 1¼ inch thick. Stirrups are to be made of ¾-inch square iron with large square nuts, and washer plates are to be 6 in. × 3 in. × ¼ in. thick. All timber for wheels is to be seasoned white oak, except braces, which are to be of pine or poplar.

STEAM PLANT.

152. Main boilers.—There will be seven boilers of the usual Mississippi River type, of 44 inches mean diameter and 30 feet long, each boiler having four flues of 11 inches outside diameter. The boilers will be built in accordance with the rules of the Board of Supervising Inspectors of Steam Vessels for a working pressure of 170 lb. per square inch. The shells are to be of marine steel $\frac{7}{100}$ inch thick and 60,000 to 65,000 lb. tensile strength. All holes will be drilled and longitudinal seams double riveted. The rings will be as long as practicable, and the longitudinal seams will be above the fire line. The flues are to be lap-welded tube in 3-feet sections and $\frac{5}{100}$ inch thick, the joints carefully and tightly fitted into each other in a thoroughly first-class manner. The boiler heads must be annealed after flanging; the back heads will have full-sized manholes at top, and front heads will have large handholes at bottom. Manhole doors are to be "Eclipse" or other equally good. A

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certificate of inspection of the boilers must be filed with the engineer officer in charge before the Government tests begin.

153. Casing, breeching, and chimneys.—The boilers will be set in three separate batteries, and will have neat, substantial cast-iron fronts, fitted with fire, poker, and ash doors, grate bars and bearers. The casings are to be made of sheet steel, No. 12 B. W. G., strengthened with angle-iron flange around top edge and at sides and bottom, and will be provided with all side stays and bottom stands necessary. The breechings are to be of good design, made of sheet steel, No. 8 B. W. G., and adequately supported. The chimneys will be 42 inches in diameter and 70 feet high above grate bars, and are to be made of sheet steel, the lower half No. 12 B. W. G., and the upper half No. 14 B. W. G., and will be strengthened with three angle bars 2½ in. × 2½ in. × 4 lb., running full length on the inside. The tops of chimneys will be finished with a 3-inch angle-bar ring, and all eyebolts, guy rods, turnbuckles, and fastenings will be provided. The usual casings from boiler to hurricane decks are to be made of sheet steel, No. 16 B. W. G., and will be fitted in place with proper deck rings and umbrellas in a thoroughly first-class manner.

154. Steam and mud drums.—Each battery will have a steam drum 30 inches in diameter and of requisite length, connected to each boiler by legs 10 inches in diameter and 6 inches long, double riveted to each. Manholes and doors similar to those on boilers will be put in heads. A main steam branch 6 inches in diameter will be riveted on each drum, and a dry pipe will be fitted on the inside. Steam branches for auxiliary lines and reinforcing plates will be put on, as required. Two mud drums, 16 inches in diameter, for each battery will be connected to each boiler by legs 8 inches in diameter. A handhole will be put in each head, as large and as near the bottom as practicable.

155. Brick work.—The boilers are to be built in, in a thoroughly first-class manner, with the best quality of fire brick in furnaces, bridges and walls, and second quality fire brick in fire bed and furnaces below grate bars. The covering tiles are to be of first-class quality; the ash pans to be lined with split brick; and throughout the whole of setting care must be taken to reduce the weight as far as possible consistent with good work.

156. Fittings and valves.—The boilers are to be furnished with all the usual and necessary fittings. Each boiler is to have one spring-loaded safety valve, mounted on a flanged branch riveted to shell. There will be three try-cocks in each wing boiler of each battery and two in center boiler; feed and check valves for each battery; four 2-inch blow-off valves for forward and four for after mud drums, with internal perforated pipes and auxiliary gate valves in each overboard pipe; one 6-inch main steam valve for middle battery and two 5-inch for side batteries, and all auxiliary valves for other steam branches. All valves for steam and feed or that are subject to high pressure are to be "extra heavy" and adapted to the purpose for which they are to be used. All valves 2½ inches and under are to be entirely of brass, unless otherwise sanctioned for special requirements by the engineer officer in charge, and in no case will the ordinary light commercial valve be accepted. It is advisable that uniformity in the make of valves be maintained as closely as possible, especially of those that have renewable valve discs. All connections 2 inches and upwards are to be made by flanged branches riveted to boilers. All fittings must be approved by the engineer officer in charge.

157. Steam pipes.—All steam and feed pipes above 2 inches diameter are to be of lap-welded tube, connected by flanges, and put on according to the rules of the Board of Supervising Inspectors of Steam Vessels. The main steam branches from steam drums will be 5 and 6 inches diameter, connecting by a cross on center line of boat and running thence 10 inches diameter to main engines, where it will be carried forward at reduced size to winches, etc. All bends in these pipes must be of large radius and very neatly bent. The auxiliary steam line will be 3 inches diameter and will be connected with auxiliary boiler, capstans, fire pump, siphons, electric-light and shop engines. All pipes 2 inches and over to be connected by flange unions; all screwed unions throughout the boat must be of brass and of first-class make; and all screwed fittings must be of malleable iron.

158. Exhaust pipes.—The exhaust from the main engines and jet pumps will be connected with condenser; and the exhaust from propelling engines, air pump, steam winches, electric-light and shop engines will be connected with heater. The large pipes are to be made of sheet steel, No. 14 B. W. G., with end or flanged sections made of copper ¼ inch thick, in the manner of the best river practice. The exhaust from heater must be provided with the ordinary water catcher, outlet to atmosphere, valve for same, and blast nozzles of copper for chimneys. The exhaust pipes from winches, air pump, electric-light and shop engines are to be fitted with straightway shut-off valves. The capstans are to exhaust through sides of hull.

159. Auxiliary boiler.—This boiler is to be of the vertical submerged-tube type, 42 inches in diameter and 9 feet high, with shell extended to form ash pan. All the plates used in the construction of this boiler are to be marine steel of 60,000 to 65,000 lb.

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tensile strength. The shell will be $\frac{31}{100}$ inch thick; the fire box and cone will be $\frac{34}{100}$ inch thick, and the heads $\frac{37}{100}$ inch thick. The shell will be double riveted in the longitudinal seams, and all holes will be drilled; and the fire box and cone will be efficiently stayed for a working pressure of 170 lb. per square inch. The boiler is to contain about 100 tubes, 2 inches in diameter and not less than 42 inches long, and must be built according to the rules of the Board of Supervising Inspectors of Steam Vessels. A chimney of suitable size will be provided, with all the necessary casings, deck rings, and guys; and the boiler will be set in place, all mountings fitted, and shell covered with approved magnesia nonconductor 2 inches thick, covered with canvas and painted. The bottom of the shell will have a 2-inch angle-bar ring, riveted on the outside and to the base plate, which last is to be made of $\frac{1}{2}$-inch steel plate, square in form and flanged on all four sides about 3 inches deep, with a return flange outwards of 2 inches width by which the boiler will be secured to deck. The bottom of the ash pan will be lined with brick. The boiler will have three mud ports at the bottom and three on the level of the furnace crown; and will be provided with grate bars, glass water gauge, three gauge cocks, one 6-inch diameter steam gauge with brass case, spring safety valve, blow-off valve, one 1-inch Metropoliton injector or other of equally good make, fitted to boiler by connection independent of blow-off, and one $2\frac{1}{2}$-inch main steam valve of "extra heavy" pattern.

160. Steam and other gauges.—The following gauges will be required and must be set in convenient places and be properly mounted and connected:

Three (3) $8\frac{1}{2}$-inch pressure gauges to 200 lb., brass case, for boilers.
One (1) 10-inch pressure gauge to 200 lb., nickel plated, for main steam in engine room.
One (1) $8\frac{1}{2}$-inch pressure gauge to 160 lb., nickel plated, for jet pump.
One (1) $8\frac{1}{2}$-inch pressure gauge to 80 lb., nickel plated, for main pump.
One (1) 10-inch vacuum gauge, nickel plated, for condenser.
One (1) 6-inch pressure gauge to 80 lb., brass case, for operator.
One (1) 6-inch vacuum gauge, brass case, for operator.
One (1) 6-inch pressure gauge to 200 lb., brass case, for auxiliary boiler.
One (1) 6-inch pressure gauge to 80 lb., for steam heating pipes for engine room.
One (1) 6-inch pressure gauge to 80 lb., nickel plated, in office.

161. Boiler and steam-pipe coverings.—The tops of boilers and the steam drums and connections must be covered with magnesia block of approved quality, 2 inches thick, properly wired, and covered with canvas. All steam pipes must be covered with same quality of magnesia of the regular thickness, and must be neatly finished at the flanges, connections, and joints, covered with canvas and painted and banded in the usual manner. The covering must not be put on until boilers and pipes have been tried under steam and everything found to be perfectly tight.

162. Feed and fire pumps.—These will be two horizontal duplex pumps with outside packed plungers about 5 inches diameter and 10 inches stroke, each having a capacity of 80 gallons per minute when running at average working speed. These pumps must have brass bushes in glands and stuffing boxes of water cylinders, and be provided with all lubricators, etc. The pumps are to be arranged in such a manner that either or both can be used for either feed or fire purposes, and straightway valves are to be used in these connections. The suction is to be taken from the hot well and also from the river, for which suitable connections to hull will be made. A fire main will run on each side of house below carlins, with four branches on main deck, four on boiler deck, and four on hurricane deck. Each branch must be fitted with a valve and hose coupling for 2-inch diameter hose. Twelve lengths of 2-inch rubber-lined cotton hose, each 50 feet long, must be supplied, together with 6 nozzles and a hose key and rack for each branch. All the above fittings and hose must be of approved make.

163. Heater.—A feed-water heater of the usual steamboat type is to be supplied; the feed pipes inside of heater to be drawn-brass tubes connected by flanges.

PLUMBING AND TINNING.

164. Staterooms.—Each of the three staterooms forward is to be fitted with a marble corner slab, 22 in. × 22 in., 10-in. back and 14-in. basin, nickel-plated brass faucets for hot and cold water, etc., complete.

165. Officers' wash room.—This will be fitted with five iron enameled washbowls with sectional slabs, with brackets and union strips nickel plated, and nickel-plated faucets for hot and cold water.

166. Officers' bathrooms and closets.—A $5\frac{1}{2}$-ft. white enameled roll-rim bath tub is to be fitted in each of the bathrooms, with nickel plated faucets for hot and cold water and all other accessories complete. One water-closet in forward bathroom and two in officers' closet will be fitted with earthenware front-outlet plain pedestal bowls,

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7-gallon copper-lined siphon flush tanks, with nickel-plated flush and supply pipes and double-cover seats. The woodwork is to be oak, with plain round corners.

167. Crew's bathrooms.—Two 5½-feet white enameled roll-rim bath tubs are to be fitted in the rooms aft of crew's quarters, with all fittings similar to those in officers' bathrooms.

168. Crew's wash room.—The crew's wash room on starboard guard is to be fitted with four iron enameled washbowls, with sectional slabs similar to those described for officers' wash room.

169. Crew's closets.—The crew's closet on the port guard aft of paddle box is to be fitted with hopper closets having suitable flushing arrangements, and also an earthenware urinal having a flushing trough inside of paddle box.

170. Sinks.—One iron white-enameled sink 40 in. × 20 in. will be placed in pantry, one 30 in. × 20 in. in kitchen, and one 30 in. × 20 in. in laundry, each to be fitted with hot and cold water connections, waste pipes, and brackets for supporting sinks. Traps will not be required for kitchen and pantry sinks, but the waste pipes must be of large size and be run overboard by an independent connection.

171. Workmanship.—All plumbing and pipe-fitting will be done in the most workmanlike and sanitary manner, and will be a thoroughly first-class job in every respect. All cold-water service pipes will be connected with tank on roof, and the hot-water service pipes for all baths and wash rooms will be connected to hot-water tank.

172. Tinning.—Four (4) downspouts from the corners of the pilot house, 1½ inches in diameter; five (5) on each side from skylight roof to hurricane deck, 2 inches in diameter; five (5) on each side of hurricane deck to boiler deck, 2½ inches in diameter, and five (5) scuppers on each side of boiler deck, 3 inches in diameter, will be provided; all to be made of galvanized iron not less than No. 22 B. W. G. The necessary speaking tubes, bell tubes, and trumpets will be provided and fitted up in a complete and first-class manner.

173. Service pipes.—A complete system of hot and cold water pipes will be fitted to all wash basins, baths, and closets throughout the boat. The kitchen, pantry, and laundry hot-water service will be connected to the range boiler.

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174. Workshop and machine tools.—The space between the jet pump and bunker will be used as a machine shop and will be fitted up with a vertical engine, 7-inch cylinder, and 9 or 10 inch stroke, and all the necessary shafting, hangers, pulleys, and belts for operating all the machines. The following machine tools are to be supplied and must be of approved make:

One (1) 24-inch swing screw cutting lathe, with compound rest and rod feed; bed to be 16 feet long, and the lathe to be provided with full set of change gears, which must include wheels for cutting pipe threads, large and small face plates; one 20-inch four-jaw chuck, one 9-inch three-jaw chuck, steady and following rests. The tailstock is to have a set-over for turning taper.

One (1) 25-inch swing vertical drill press with back gear, and power feed with quick-return motion.

One (1) 18-inch stroke crank shaper, with swivel vise.

One (1) bolt and pipe threading machine, to cut bolts from ¼ inch up to 2 inches, and pipes from ¼ inch up to 3 inches, with a full set of both bolt and pipe dies and of machine taps from ¼ inch to 2 inches; the fittings to include cutting-off knife, chuck for gripping nuts, and holder for taps.

One (1) emery grinder with two wheels, 12 in. × 2 in., and rests suitable for tool grinding.

Two (2) portable vise benches, one 6 ft. × 3 ft. fitted with 2 vises and 2 drawers, and one 3½ ft. × 2½ ft. fitted with one vise; these benches to be fitted up in a very substantial manner.

One (1) blacksmith's forge, 28 in. × 40 in., with fan blower, to be set up and provided with necessary smokestack, etc.

175. Small tools.—The following small tools are to be supplied, and must be of first-class quality throughout and of approved make unless otherwise specified:

One (1) anvil, 200 lb.
One (1) set of firing tools for each battery of boilers.
One (1) set of firing tools for auxiliary boiler.
Six (6) short-handled coal shovels.
Two (2) long-handled coal shovels.
One (1) set of drop-forged steel wrenches for each engine, machine, and pump.
One (1) set of drop-forged steel wrenches for each capstan engine.
Three (3) machinists' hand hammers.
Twelve (12) machinists' chisels, assorted.
One (1) copper or rawhide hammer.

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One (1) blacksmiths' hand hammer.
One (1) twelve-pound sledge hammer and handle.
One (1) six-pound sledge hammer and handle.
One (1) set of 12 blacksmiths' tongs.
One (1) set of blacksmiths' tools. (1 set swages, tops and bottoms, ½ in., 1 in., 1½ in., 2 in., 2½ in., 3 in.; 1 set fullers, tops and bottoms, ½ in., 1 in., 2 in.; 1 flatter, 3 in.; 2 set hammers, 1½ in., 2 in.; 2 cutting chisels, 1 each, hot and cold, 1½ in.; 6 punches, 1 each square and round, ½ in., ¾ in., 1 in.; 1 set heading tools, ⅜ in. to 1 in., by eighths.)
One (1) swage block.
One (1) boiler rachet (12 inches).
Six (6) steel drills for boiler ratchet, ⅜ in. to 1 in., by eighths.
One (1) medium-size melting ladle.
One (1) small-size melting ladle.
One (1) portable forge, Buffalo No. 4.
Three (3) machinists' parallel vises, 5½-inch jaws, Prentiss or equal.
One (1) pipe vise, hinged, to take pipe up to 3 inches diameter.
One (1) No. 1 Barnes 3-wheel pipe cutter.
One (1) No. 2 Barnes 3-wheel pipe cutter.
One (1) set of pipe taps, ¼ in., ⅜ in., ½ in., 1 in., 1¼ in., 1½ in., 2 in.
Two (2) pairs No. 1 adjustable pipe tongs.
Two (2) pairs No. 2 adjustable pipe tongs.
Two (2) pairs No. 4 adjustable pipe tongs.
One (1) No. 3½ Brock's chain tongs.
One (1) six-inch Stilson wrench.
One (1) ten-inch Stilson wrench.
One (1) eighteen-inch Stilson wrench.
One (1) six-inch Coe's monkey wrench.
One (1) twelve-inch Coe's monkey wrench.
One (1) eighteen-inch Coe's monkey wrench.
One (1) brass oiler set (6 pieces).
Four (4) oilers, steel, long spout, quart.
Four (4) oilers, steel, long spout, pint.
Four (4) oilers, steel, 3⅜ inches diameter, 3-inch nozzle.
Three (3) galvanized-iron oil tanks, 60 gallons, with pumps, measures, and funnels complete.

176. Spare parts of machinery.—The following spare parts are to be furnished; each piece must be fitted in place and all ready for use:

Two (2) bronze sleeves for shaft stuffing boxes of main pump.
Two (2) bronze glands for shaft stuffing boxes of main pump.
Two (2) bronze water rings for shaft stuffing boxes of main pump.
Two (2) bronze worms for hauling winches, one right and one left.
Two (2) hoisting sheaves with bronze bushes.
Four (4) clamps for rubber connections.
Twelve (12) nozzles for water jets with ¾-inch outlets.
A set of grate bars equal in number to half the number in actual use.

177. Steam whistle.—The whistle will be 8 inches in diameter, long bell, and will be placed in position required. The steam pipe will have an independent connection to each battery of boilers, with a shut-off valve to each. The whistle valve will be placed where most convenient and be wired to pilot house.

178. Fire pails.—Four (4) stands for fire pails will be provided and set on the skylight roof, each containing six (6) best galvanized-iron fire pails, large size.

179. Water tanks.—A combined water tank and filter 9 ft. × 3 ft. × 20 in. deep, made of galvanized iron, No. 12 B. W. G., and fitted with iron covers, will be provided for the cold-water service, and a tank of similar size and make, but fitted with a steam heating coil, will be provided for the hot-water service. Both of these tanks will be placed on hurricane deck. A small expansion tank will be placed in kitchen where convenient, and will receive the water of condensation from coil in hot-water tank, and will also have a connection to filter tank operated by a ball valve. This tank will work in connection with the boiler of cooking range. The hot and cold water tanks will be supplied by the fire pump, and all connections, valves, and overflow pipes necessary for the complete fitting out of this service will be provided.

180. Steam heating.—A complete system of steam heating will be installed, with coils as follows: Two (2) in office, four (4) in officers' mess room, one (1) in each forward bath and wash room, two (2) in crew's mess room, four (4) in crew's quarters, one (1) in each crew's bathroom, and (1) in pilot house. The length and number of returns of coils will be regulated by the size of rooms to be heated. A reducing valve will be placed near to boiler to reduce the pressure in heating system to about 25 lb. per square inch; and a spring-loaded relief valve will be placed near end of main line of pipes in engine room, and also a pressure gauge in engine room

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and one (1) in office. The whole will be fitted with all necessary radiator valves, air cocks, steam trap, drainpipes, and screens to protect the woodwork.

181. Stoves.—One plain heating stove with square base and about 18-inch fire pot will be placed in office, and one of similar make with about 20-inch fire pot will be placed in officers' mess room. These stoves will be set on zinc stands and will be secured to deck. A kitchen range must be provided, of wrought steel and of approved make, large enough to cook for about 50 persons. It must have two ovens and single shelf, pouch feed door for soft coal, and water back, and must be furnished with one 66-gallon pressure boiler, one set of waffle irons, 4 steel-ribbed roasting pans, and 4 Russia-iron bread pans. The laundry must be provided with one wrought-steel stove, to heat four irons each side. All the stoves are to be adapted for soft coal, and will be set up in place with smooth stovepipes and roof ventilators, and have housings, smokestacks, and caps of No. 22 galvanized iron. The smokestacks will be so arranged and of such height as not to be an inconvenience to the pilot house.

182. Bedsteads and mattresses.—Each of the three staterooms forward will be furnished with a white enameled iron bedstead of plain design, 3 feet wide, pillars $1\frac{1}{16}$ inches diameter, with an all-metal, steel-wire center support, woven-wire mattress to suit. Each of the other ten staterooms in forward cabin will be furnished with a two-story, all-iron bedstead, white enameled, 2 feet 9 inches wide, pillars $1\frac{1}{16}$ inches diameter, and all-steel-wire mattress to suit. The laundress' room will be furnished with a single all-iron bedstead, black enameled, 2 feet 9 inches wide, pillars $1\frac{1}{16}$ inches diameter, and all-steel-wire mattress to suit. The cook's and waiters' room and the crew's quarters will be furnished with 19 two-story all-iron bedsteads, black enameled, 2 feet 9 inches wide, pillars $1\frac{1}{16}$ inches diameter, and all-steel-wire mattress to suit. All bedsteads must be of approved make.

183. Flagstaffs.—The forward flagstaff will be placed abaft the pilot house and the after one at end of skylight, properly stepped and braced and furnished with halyards and cleats.

184. Painting.—All woodwork above main deck will be painted three coats of pure white lead and linseed oil. The interior of cabin will be painted with one coat of shellac, three coats of flat color, and one of zinc gloss. All knots will receive one coat of shellac. Three (3) name plates for sides of pilot house will be provided, having the name of boat in gilt letters on a dead black ground. The lettering on other parts of boat will be done as directed. In painting metal work all scales and traces of oxidation must be removed before applying the first coat. The outside of hull will receive two coats of red lead and pure linseed oil before launching and the inside will receive one coat of similar paint before launching and another after all work is finished and the bilges cleaned out. The machinery and other ironwork will receive two coats of good oil paint of such colors as may be selected, the last coat to be put on after all work is done and preliminary tests are made.

185. Refrigerating plant.—Separate bids are required on a refrigerating plant which will have a capacity sufficient to make about half a ton of ice per 24 hours and cool a storage room about 12 feet long, 4 feet wide, and 7 feet high in the clear. All the machinery must be furnished and installed in a satisfactory manner. The freezing tank is to be provided with ice molds and filter, and tank and storage room must be built in approved manner. It is proposed to place the ice tank on the starboard guard forward of wheel box and the storage room similarly on the port guard. The machinery is to be located as most convenient when the spaces to be occupied are known. The machine will not be run continuously, but in periods of 6 or 8 hours, with the same stoppage between runs. The plant must be run satisfactorily for four days before being accepted. Specifications and general drawings of this plant must be submitted with proposals as required by paragraph 36.

H. E. WATERMAN,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

MISSISSIPPI RIVER COMMISSION, OFFICE OF THE SECRETARY,
St. Louis, Mo., June 21, 1898.

APPENDIX 1 C.

REPORT OF ASST. ENGINEER A. T. MORROW ON SURVEY WORK ALONG THE UPPER RIVER, AND ON THE COMPARISON OF THE RESULTS OF THE LOW-WATER SURVEY OF 1897–98 ALONG THE LOWER RIVER WITH THE RESULTS OF PREVIOUS SURVEYS.

ST. LOUIS, MO., *April 10, 1899.*

CAPTAIN: I have the honor to submit the following report on the work of the survey party which operated under my direction during the last season in the State

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of Minnesota, working from St. Paul northward, and on the comparison of the results of the low-water survey of 1897–98 along the lower river with the results of previous surveys.

Survey work along the upper river.—On the 24th of May I left St. Louis, Mo., accompanied by my foreman, and proceeded to Minneapolis, where I was engaged for a time in receiving outfit and in making preparations for the season's work. Other members of the party joined me from time to time during the last days of May and the first part of June. On the 31st of May I set up camp in northeast Minneapolis. On the 3d of June work was begun with a small force, and the regular work of the season was taken up on the 6th of June.

The party when in full working order consisted of 26 employees and 5 teamsters with teams, the latter being furnished under contract.

The party was organized as follows: A. T. Morrow, chief of party; W. S. Williams, precise-level observer; F. G. Ray, observer on secondary triangulation; O. N. Axtell, location of bench marks and observer on tertiary triangulation connected therewith; W. C. Lemen and E. E. Whitehead, recorders. Foreman J. B. Moore was placed in charge of the subparty building triangulation stations.

The party was quartered in a camp of 11 tents, which was moved by teams as the work progressed. The teams used to move camp outfit were occupied at other times in transporting subparties to and from their work.

The work of triangulation was begun in the vicinity of Fort Snelling, the last line of the triangulation of 1895 being taken as a base. From that point the work was carried northward, embracing points on both sides of the river and having triangle sides of about 4 miles in length on the average. With the exception of the base lines and the stations immediately connected therewith, the triangulation system, mostly, followed the locations selected by George H. French, who made a reconnaissance in advance of the triangulation party. The work of building stations proved to be unusually heavy. The country above St. Paul is mostly level and to a considerable extent is covered with timber. Hills of sufficient height to furnish clear lines of sight from point to point, except in rare cases, could not be found. Under such circumstances it became necessary either to cut lines through the timber or to build stations of sufficient height to carry the lines of sight above the timber. The latter course in almost all instances proved cheaper and more expeditious. Of 98 stations occupied during the season, 10 only were ground stations; 10 others had 4-foot tripods, and the remaining 78 were provided with double-concentric scaffolds, for supporting instrument and observers, of heights varying from 10 feet to 76 feet and averaging 33 feet.

The entire distance covered by the triangulation from Fort Snelling to Aitkin is 175 miles. One hundred and one secondary triangles were closed during the season.

Four base lines were measured along the line of the work at the following places: Monticello, Rice, Brainerd, and Aitkin. The stretches between the base lines embraced from 22 to 27 triangles each. The steel tape and other apparatus used in the base-line measurements are the same that have been used heretofore, and the methods employed in the work remain practically unchanged. Observations for azimuth were made at the several base lines. In this work the readings on the striding level were dispensed with, and alternate observations on the star and its reflection from the surface of Mercury were substituted therefor. In other respects the methods prescribed in the printed instructions were followed. The results indicate a decided gain by the change of method, which is not surprising in view of the high latitude at which the observations were taken and the somewhat worn condition of the instruments used.

Within the system of secondary triangulation enough tertiary triangulation was done to locate the several bench marks. These were placed along the river banks in pairs of one P. B. M. and one B. M. on each "stone line" at intervals of 3 miles.

A precise-level party under W. S. Williams was attached to the triangulation party. The work of this party began at St. Paul, where it was connected with the P. B. M.'s of 1891, and terminated at the Aitkin base line. The line followed the left bank of the river as nearly as practicable, and was connected with the several "stone line" P. B. M.'s and as many of the triangulation marks as were easily accessible.

The permanent marks used consist of the usual vitrified tile for subsurface mark, and for surface mark an iron pipe with a fixed brass cap provided for stamping latitude, longitude, and elevation above sea. The bottoms of the pipes are split and turned outward to prevent "heaving" by frost.

On November 15 the work was completed to the Aitkin base line. The property was then stored in Aitkin and the party disbanded.

During the last month of the season the progress of the work was seriously retarded by the high timber. After selecting the highest ground available and building stations of from 60 to 75 feet in height the lines sometimes failed to clear the timber. The advent of the swamps above Aitkin will still further increase the difficulties.

I am inclined to think that some modification of the plan of operations will have

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to be devised for the continuance of this work above the limit of the last season's operations.

Appended hereto are tabulations showing the extent and results of the work. Descriptions of triangulation points and bench marks, together with geographical positions of same, will be submitted later.

There were 101 triangles closed with a mean closure for the season of 1.14 seconds; 48 triangles closed large, 1.17 seconds, and 53 triangles closed small, 1.11 seconds.

There were 130 stone-line bench marks established and located, and 34 tertiary points, such as church steeples, court-houses, etc., located.

TABLE NO. 1.

Location of base line.	Opposite Monticello, Minn.	Below Rice, Minn.	Brainerd, Minn.	Aitkin, Minn.
Number of triangles between base lines.	31	24	30	22
Length of base lines.....feet.....	5,401.1575	5,700.4799	5,400.6708	4,798.4793
Length of base lines.....meters..	1,646.2580	1,737.4907	1,646.1097	1,462.5634
Discrepancies between measurements ..	1 in 201,000 1 in 1,475,700 1 in 232,700	1 in 2,969,000	1 in 438,400	1 in 1,304,000
Discrepancies between measured and computed lengths of bases	1 in 622,700	1 in 34,960	1 in 116,900	1 in 48,380

TABLE NO. 2.

Base.	Observed azimuth.	Sets of observations.	Discrepancies between sets of observations.	Discrepancies between observed and computed azimuths before adjustment.
	° ′ ″		″	″
Monticello, Minn., east base to west base.....	89 58 18.48	2	0.26	7.01
Rice, Minn., river base to back base	270 36 14.39	5	8.33	.85
Brainerd, Minn., north base to south base.....	357 44 07.81	5	4.95	1.27
Aitkin, Minn., lower base to upper base	267 06 25.74	5	5.57	2.06

Comparison of the results of the low-water survey of 1897–98 with the results of previous surveys.—The survey of 1897–98 began at Scot Bluffs, 5 miles above Baton Rouge, and extended to Carrollton, a distance of 131 miles. This section of the river is completely protected by levees, has comparatively stable banks, and at extreme low water it practically subsides to Gulf level and has but little current. It may therefore be considered a lower-river section, and such conclusions as are drawn from its examination may properly apply to the lower river only.

The survey and the methods of reducing and comparing its results are similar to those described in previous reports and need not here be repeated. (See Mississippi River Commission Report, 1897, p. 3672–3674; Report 1898, p. 3241–3244.)

Between Scot Bluffs and Donaldsonville, a distance of 58 miles, the following comparisons have been made: Survey of 1897–98 with survey of 1895–96 on 391 cross sections, 26,052 elevations being used; survey of 1897–98 with survey of 1882–83 on 170 cross sections, and survey of 1895–96 with survey of 1882–83 on 170 cross sections.

Between Donaldsonville and Carrollton, a distance of 73 miles, the survey of 1897–98 was compared with survey of 1893–94 on 489 cross sections, 31,416 elevations being used.

Some tabulations showing averages of cross-section elements by stretches and by reaches have been prepared, to accompany this report; also a series of tabulations showing changes in mean cross-section elements, so far as such changes have been determined by the several surveys. These latter tabulations set forth more clearly than I can otherwise express the changes in detail. Their examination, however, leads me to some general conclusions in regard to this portion of the river, which are submitted as follows:

(1) At the time of the survey of 1897–98, following the great flood of 1897, the river was slightly larger and deeper than at the time of any previous survey. From Donaldsonville to Carrollton, the average cross section to top of bank in 1897–98 was 1.1 per cent larger and 2.1 feet deeper (thalweg depth) than in 1893–94. From Scot Bluffs to Donaldsonville, the average cross section to top of bank was 3.7 per cent

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larger and 8.6 feet deeper (thalweg depth) than in 1895–96, and 2.2 per cent larger and 1.2 feet deeper than in 1882–83.

(2) The greatest changes have taken place below the low-water line, but these changes have been mainly of a temporary character. At times of small floods or rises in the river and in times of comparatively low water the sediment from above has been arrested by the slack water or the slower current of the lower river and deposited in the bed of the stream and has afterwards been removed by the stronger current of the great floods.

The survey of 1895–96, which followed two years of comparatively low water, when compared with the survey of 1882–83, which followed a great flood, shows a decrease in average area of cross section below the low-water line of 5.5 per cent and a decrease in average maximum depth of 6.6 feet. This same survey of 1895–96, when compared with the survey of 1897–98, shows that after the flood of 1897 the river had increased in area of average low-water cross section by 6.6 per cent and in average maximum depth by 8.6 feet. When it is taken into consideration that a period of more than a year, without a great flood, followed the survey of 1895–96, and that several months of comparatively low water preceded the survey of 1897–98, it may be safely inferred that the above comparisons do not fully express the extent of the alternate changes that have taken place in the bed of the stream.

(3) There has been a general tendency toward permanent enlargement of the stream above the low-water line. Comparing survey of 1882–83 with survey of 1895–96, the river above the low-water line is seen to have increased 5.4 per cent in area of average cross section. Comparing survey of 1882–83 with survey of 1897–98, the average area of cross section above the low-water line is shown to have increased 4.6 per cent. This last-mentioned change represents the resultant of many changes during a period of fifteen years and shows a decided increase, notwithstanding a small change in the opposite direction immediately preceding the last survey, which decrease was probably exceptional and due to unusual conditions immediately preceding the flood of 1897.

(4) The inability of the flood of 1897 to carry away from the lower river the accumulated deposits of the preceding three years of comparatively low water is strongly suggested, if not fully proved, by some facts which have developed in this investigation. The flood water from above, reaching the lower river, already laden with sediment and unable to take up the accumulation of loose material in the bed of the stream, has seemingly pushed it aside, or, by some process of exchange, has effected a similar result by removing material from along the line of the strongest current and making corresponding deposits in the slack water about and beyond the banks. Both above and below Donaldsonville the average maximum depth and the area of the average cross section below the low-water line were considerably increased, while the area of the average cross section above the low-water line was diminished.

Above Donaldsonville the width of the stream in the bend has diminished, on the average, the greatest contraction being in proximity to the large sand bars which lie under the prominent points.

Below Donaldsonville the change is more marked in a contraction of width on the low-water line. This is not confined to bends nor to the proximity of sand bars, but prevails generally, and amounts to 24 feet on the average.

This deposit of material about and above the low-water line and the enlargement of the adjacent channel during the same flood, have led me to believe that the operations have been largely a transfer of loose materials from the line of the strongest current to the slack water, not far below. The failure of the material shown to have been deposited about the banks to equal in quantity the material removed from the channel may be accounted for by the well-known fact that during times of overflow considerable quantities of sand and silt find permanent lodgment in the areas lying between the banks and the levees, about which the late surveys furnish no data.

(5) Since the area of the average cross section, following the flood of 1897, was slightly greater, so far as is known, than at any time before, and both the average maximum and mean depths have increased, and since the river, in the great emergency, is shown to have removed material from along the line of its most rapid discharge, thereby enlarging its bed when such enlargement would do the most good, and to have removed the surplus material to the slack water, where such material would do the least harm, it may be safely concluded that the capacity of the river to discharge flood waters has been more than maintained.

Respectfully submitted.

A. T. MORROW, *Assistant Engineer.*

Capt. MASON M. PATRICK,
Corps of Engineers, U. S. A.

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*

[Referred to the Cairo Astronomical Post.]

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
⊙ South Base (U. S. C. & G. S.)	44	55	00.67	20.7	93	10	01.96	43.0	56	46	34.2	236	44	39.1	⊙ Boshart	4,273.5
									110	31	27.4	290	27	32.0	⊙ Powderhorn	7,805.0
									147	59	52.1	327	57	56.1	⊙ Prospect Park	6,792.5
									78	59	50.2	258	58	20.1	△ Soldiers' Home	2,851.2
									181	08	29.6				△ City Hall	
⊙ Boshart	44	53	44.79	1,382.5	93	12	44.89	984.9	143	38	07.0	323	36	06.6	⊙ Powderhorn	6,303.4
									203	19	25.1	23	19	50.0	△ Soldiers' Home	1,957.7
									155	23	42.7				△ City Hall	
									300	05	44.1				△ Fort Snelling Flagstaff	
△ Soldiers' Home	44	54	43.02	1,327.9	93	12	09.55	209.5								
⊙ Powderhorn	44	56	29.18	900.7	93	15	35.85	775.1	230	45	09.6	50	47	09.1	⊙ Prospect Park	4,786.0
									172	46	39.4	352	46	22.0	⊙ Guaranty Loan Tower	4,273.1
									173	53	01.9	353	52	48.0	△ City Hall	4,044.4
⊙ Prospect Park (U. S. C. & G. S.)	44	58	07.24	223.5	93	12	46.22	1,012.9	105	57	45.5	285	55	28.6	⊙ Guaranty Loan Tower	4,413.1
									162	01	16.6	342	00	23.5	⊙ Windom	5,332.1
									103	32	04.5	283	29	51.1	△ City Hall	4,254.9
⊙ Guaranty Loan Tower	44	58	46.51	1,435.6	93	15	59.87	1,311.6	161	15	14.5	341	14	24.8	⊙ Peck	4,786.3
									213	54	30.3	33	55	54.1	⊙ Windom	4,650.8
△ City Hall, Minneapolis	44	58	39.45	1,217.7	93	15	55.02	1,205.4								
△ Exposition Building	44	59	10.27	317.0	93	15	26.14	572.7								
⊙ Windom	45	00	51.53	1,590.7	93	14	01.38	30.2	99	15	57.4	279	13	43.9	⊙ Peck	4,187.1
									173	33	46.4	353	33	26.3	⊙ Mulcara	5,548.8
									31	24	55.0				△ City Hall	
									115	31	24.7				△ Soo Line Shops Chimney	
⊙ Peck	45	01	13.32	411.2	93	17	10.13	221.8	215	55	03.7	35	56	57.1	⊙ Mulcara	5,978.7
									158	04	20.2	338	02	53.6	⊙ Palmer	7,164.3
									329	02	46.3	149	03	59.8	△ Exposition Building	4,429.0
									270	24	58.7	90	26	28.0	△ Soo Line Shops Chimney	2,766.3
									340	52	23.0				△ City Hall	
									344	46	30.0				Engine House Tower	
△ Soo Line Shops Chimney	45	01	12.65	390.5	93	15	03.79	83.0								
⊙ Mulcara	45	03	50.14	1,547.9	93	14	29.82	652.4	106	17	54.9	286	14	34.8	⊙ Palmer	6,440.5
									153	23	22.8	333	21	06.2	⊙ Dunn	9,411.2
									8	41	47.6				△ Soo Line Shops Chimney	4,918.2
									11	00	49.6				△ City Hall	
● Palmer	45	04	48.60	1,500.4	93	19	12.45	272.3	196	31	02.9	16	32	06.5	⊙ Dunn	6,893.2
									152	26	08.9	332	24	31.5	⊙ Kilmer	6,164.2
									334	36	05.1				△ Exposition Building	11,560.7
									339	12	34.8				△ City Hall	
									184	59	07.4				Church Spire	

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*—Continued.

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
Dunn	45	08	22.67	699.9	93	17	42.75	934.2	76	38	33.5	256	35	57.4	Kilmer	4,946.5
									137	11	43.5	317	10	06.9	Powell	4,379.1
									350	02	46.0				Exposition Building	
									352	31	53.3				City Hall	
									265	23	05.3				Brick Schoolhouse	
									132	38	43.8				Anoka Catholic Church	
									132	16	59.5				Anoka Court-House	
Kilmer	45	07	45.59	1,407.5	93	21	22.98	502.1	202	49	34.5	22	50	34.0	Powell	4,727.2
									141	39	59.4	321	38	19.9	Howard	4,943.0
									163	06	59.3				**Anoka Catholic Church**	
									162	48	33.5				**Anoka Court-House**	
									336	54	34.5				City Hall	
									78	33	48.5				Osseo Spire	
Powell	45	10	06.72	207.5	93	19	59.01	1,288.8	84	25	31.9	264	22	52.8	Howard	4,923.1
									135	15	37.1	315	12	39.4	Carvel	7,760.1
									128	54	36.1	308	52	20.3	Anoka Catholic Spire	5,370.1
									128	14	34.4	308	12	17.7	Anoka Court-House	5,355.2
									126	54	42.4	306	52	16.1	Mill Flagstaff	5,628.8
Howard	45	09	51.17	1,579.7	93	23	43.36	947.0	174	35	31.6	354	35	13.1	Carvel	6,016.6
									135	41	46.4	315	39	12.1	**Johnson**	6,792.9
									190	33	41.4	10	34	04.7	**Anoka Catholic Church**	3,918.1
									190	19	19.2	10	19	41.7	**Anoka Court-House**	3,856.0
									185	51	47.3	5	52	00.2	**Mill Flagstaff**	3,879.4
Anoka Catholic Spire	45	11	55.94	1,727.0	93	23	10.45	228.1								
Anoka Court-House	45	11	54.06	1,669.0	93	23	11.70	255.4								
Mill Flagstaff	45	11	56.18	1,734.4	93	23	25.20	550.0								
Carvel	45	13	05.20	160.5	93	24	09.34	203.8	74	52	40.4	254	50	24.6	Johnson	4,327.3
									130	23	23.6	310	21	22.6	Carpenter	4,881.0
									328	59	12.1				Anoka Catholic Spire	2,494.7
									330	11	41.3				Anoka Court-House	2,531.2
Johnson	45	12	28.59	882.6	93	27	20.77	453.3	186	04	39.3	6	04	54.2	Carpenter	4,316.3
									117	47	57.9	297	45	37.2	Diegel	4,889.0
									130	07	11.9				Dayton Church Spire	
									280	25	43.1				Anoka Catholic Spire	
									281	04	20.8				Anoka Court-House	
Carpenter	45	14	47.62	1,470.1	93	26	59.81	1,304.3	67	11	07.0	247	08	31.3	Diegel	5,187.8
									120	20	03.1	300	17	51.4	Clark	4,685.4
									85	29	39.7	265	26	54.5	Dayton Church Spire	5,091.0
									316	37	28.8				Anoka Catholic Spire	
									318	28	51.1				Mill Flagstaff	
Diegel	45	13	42.40	1,309.0	93	30	39.01	850.9	189	31	30.0	9	31	53.9	Clark	4,439.6
									137	48	12.6	317	46	56.9	Carrow	3,460.2
									169	38	18.9	349	38	09.3	Dayton Church Spire	1,688.1
									288	30	59.8				Anoka Catholic Spire	

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◉ Clark	45	16	04.23	130.6	93	30	05.31	115.8	59	19	23.4	239	17	43.7	◉ Carrow	3,556.7
									127	06	02.6	307	04	19.4	◉ Castle	3,971.9
									20	24	42.4				△ Dayton Church Spire	3,952.3
△ Dayton Church Spire	45	14	34.60	1,068.2	93	30	52.52	1,145.8	124	54	02.9				△ Elk River School	
◉ Carrow	45	15	05.43	167.6	93	32	25.59	558.0								
									178	29	25.3	358	29	21.7	◉ Castle	4,212.0
									133	45	26.6	313	48	33.9	◉ Fritz	4,787.1
									154	13	04.7				△ Elk River School	
									295	06	35.9				△ Dayton Church Spire	
◉ Castle	45	17	21.82	673.6	93	32	30.68	668.6	74	57	02.4	254	55	13.3	◉ Fritz	3,465.5
									136	45	26.5	316	43	33.0	◉ Elk River	5,077.3
									122	11	53.4	302	10	23.2	△ Elk River School	3,265.8
									309	24	48.4				△ Anoka Catholic Spire	
									337	28	22.4				△ Dayton Church Spire	
◉ Fritz	45	16	52.64	1,625.1	93	35	04.28	92.2	178	19	41.3	358	19	36.8	◉ Elk River	4,600.3
									119	33	51.6	299	32	15.5	◉ Davis Island	3,388.3
									192	25	24.1				△ Elk River School	2,703.6
									307	48	22.3				△ Dayton Church Spire	
△ Elk River School	45	18	18.17	560.9	93	34	37.53	817.7								
◉ Elk River	45	19	21.59	666.5	93	35	10.39	226.8	43	51	53.4	223	50	21.6	◉ Davis Island	4,059.2
									82	17	49.4	262	14	43.3	◉ Williams	5,752.5
									339	55	04.5				△ Elk River School	2,084.6
									334	18	18.2				Union Church	
◉ Davis Island	45	17	46.77	1,443.9	93	37	19.49	424.7	126	42	51.1	306	41	16.9	◉ Williams	3,603.5
									89	39	56.8	269	37	40.1	◉ Baker	4,191.6
									254	37	31.3				△ Elk River School	
									311	44	54.1				Otsego Spire	
◉ Williams	45	18	56.54	1,745.5	93	39	32.11	699.5	30	51	09.8	210	50	27.4	◉ Baker	2,538.5
									109	20	20.1	289	18	19.2	◉ Varley	3,926.6
									280	25	38.5				△ Elk River School	
									307	49	32.1				Otsego Spire	
									105	30	31.3				△ Big Lake Church Cupola	
◉ Baker	45	17	45.94	1,418.3	93	40	31.85	693.9	145	21	26.5	325	20	08.1	◉ Varley	4,228.8
									83	51	37.6	263	49	30.6	◉ Lambert	3,914.9
									262	37	13.1				△ Elk River School	
◉ Varley	45	19	38.62	1,192.3	93	42	22.24	484.3	20	52	48.3	200	51	59.8	◉ Lambert	4,172.4
									64	48	20.5	244	45	20.2	◉ West Base	6,104.2
									98	08	39.4	278	05	32.0	◉ Big Lake	5,797.2
									100	29	39.6				△ Big Lake Church Cupola	
◉ Lambert	45	17	32.34	998.4	93	43	30.48	664.1	107	50	14.6	287	48	02.9	◉ West Base	4,240.6
									143	24	27.1	323	23	06.1	◉ Telephone	4,317.5
									137	58	22.0	317	56	03.2	◉ Big Lake	6,352.2
									99	30	26.8	279	26	47.6	◉ Monticello	6,811.5
									161	32	32.6	341	31	44.1	△ Big Lake Church Cupola	4,689.6
◉ Telephone	45	19	24.61	759.8	93	45	28.66	624.2	103	28	01.8	283	24	50.7	△ Monticello Methodist Episcopal Church	6,024.7
									38	59	41.2	218	58	53.5	◉ West Base	2,615.1
									355	08	38.0	175	08	44.0	◉ East Base	2,175.1
									126	41	29.0	306	40	34.2	◉ Big Lake	2,094.5
									60	30	38.7	240	28	23.5	◉ Monticello	4,759.9
									57	50	34.1	237	48	46.9	△ Monticello Methodist Episcopal Church	3,879.4
									227	56	11.4				△ Big Lake Church Cupola	

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*—Continued.

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
West Base	45	18	14.37	443.6	93	46	35.77	779.3	269	57	24.8	89	58	18.5	East Base	1,646.3
									176	20	57.8	356	20	50.7	Big Lake	3,426.5
									218	58	56.9	39	00	20.2	Big Lake Church Cupola	4,053.7
									93	14	00.9				Monticello Methodist Episcopal Church.	1,825.3
East Base	45	18	14.41	444.9	93	45	20.21	440.4	196	01	29.6				Big Lake Church Cupola	3,277.1
Big Lake Church Cupola	45	19	56.42	1,741.8	93	44	38.67	842.1								
Monticello Methodist Episcopal Church.	45	18	17.70	546.4	93	47	59.41	1,294.4								
Big Lake	45	20	05.14	158.7	93	46	45.79	997.1	34	24	39.6	214	23	19.2	Monticello	4,357.8
									116	55	23.8	296	53	01.0	Shenton	4,902.3
									278	12	54.2				Water Tank	
									25	48	30.4				Monticello Methodist Episcopal Church.	
Monticello	45	18	08.67	267.7	93	48	38.82	845.8	161	48	36.1	341	47	33.7	Shenton	6,120.1
									128	58	09.7	308	53	56.3	Ackerman	9,977.0
									252	00	19.8				Monticello Methodist Episcopal Church.	
									258	44	45.1				Monticello School	
Shenton	45	21	16.99	524.5	93	50	06.59	143.5	94	29	05.4	274	25	54.3	Ackerman	5,864.5
									144	57	07.6	324	55	48.0	Becker	4,250.8
									233	24	24.5				Monticello Methodist Episcopal Church.	
									143	04	04.7				Becker Church Cupola	
Ackerman	45	21	31.76	980.5	93	54	35.21	766.3	228	22	01.4	48	23	52.7	Becker	4,552.6
									170	12	41.8	350	12	08.8	Parks	5,925.6
									117	50	08.0	297	48	14.1	River Bank	3,936.5
									214	18	56.7	34	20	24.9	Becker Church Cupola	4,783.0
									304	45	54.1				Monticello Methodist Episcopal Church.	
Becker	45	23	09.70	299.5	93	51	58.80	1,279.3	122	34	45.6	302	32	21.3	Parks	5,231.8
									142	41	45.7				Becker Church Cupola	1,164.5
Becker Church Cupola	45	23	39.70	1,225.6	93	52	31.25	679.7								
Parks	45	24	40.91	1,263.0	93	55	21.54	468.4	31	42	53.9	211	41	33.0	River Bank	4,704.1
									74	29	11.1	254	25	43.9	Benson	6,567.9
									122	08	17.5	302	05	17.0	Clear Lake	6,500.0
									297	00	44.6	117	02	45.9	Becker Church Cupola	4,157.7
									120	20	23.9				Clear Lake Church	7,081.2
River Bank	45	22	31.27	965.4	93	57	15.19	330.5	120	11	16.3	300	09	10.0	Benson	4,461.6
									154	19	54.7	334	17	55.4	Clear Lake Church	8,406.9
Benson	45	23	43.90	1,355.3	94	00	12.49	271.7	188	55	42.8	8	56	09.7	Clear Lake	5,279.2
									131	56	29.2	311	54	02.5	Clearwater	6,021.2
									182	16	22.3	2	16	29.2	Clear Lake Church	5,338.2
									125	39	41.0				Clearwater Church Belfry	4,581.3
									128	48	52.0				Clearwater Church Spire	

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◎ Clear Lake	45	26	32.83	1,013.5	93	59	34.79	756.0	77	20	21.7	257	71	28.0
									144	43	23.3	324	41	39.6
									60	44	51.7			
									101	02	18.6			
◎ Clearwater	45	25	54.20	1,673.3	94	03	38.53	837.5	200	39	39.6	20	40	49.6
									187	37	24.4	317	34	41.1
									126	40	07.6	306	36	12.5
									330	45	14.2			
									323	15	51.6			
△ Clear Lake Church Spire	45	26	36.68	1,132.4	94	00	02.75	59.8						
△ Clearwater Church Belfry	45	25	10.38	320.4	94	03	03.69	80.2						
◎ Cater	45	28	57.48	1,774.5	94	02	00.28	6.1	88	21	37.2	268	17	43.8
									135	39	48.0	315	36	21.9
									88	01	02.4	267	55	57.2
									134	37	11.2	314	33	31.2
									130	06	42.2			
									329	33	33.1			
◎ St. Augusta	45	28	50.76	1,567.1	94	07	27.58	599.0	187	10	19.2	7	10	46.6
									144	17	27.7	324	14	57.1
									176	29	51.7	356	29	38.6
									161	11	50.7	341	10	13.1
									86	50	21.6			
									162	13	50.7			
△ St. Augusta Spire	45	28	46.83	1,445.8	94	09	08.35	181.3						
◎ Reformatory	45	32	25.17	777.1	94	06	49.19	1,067.3	87	24	29.9	267	21	31.8
									141	11	34.9	321	08	17.9
									113	54	45.3	293	54	31.4
									85	28	15.4	265	27	34.9
									320	35	46.4			
									24	09	14.3			
									124	19	39.2			
									133	55	00.4			
△ Hospital Water Tank	45	32	22.00	679.2	94	07	45.98	997.7						
△ Reformatory Flagstaff	45	32	31.25	964.8	94	07	08.71	188.9						
◎ North Star	45	32	17.15	529.5	94	10	58.74	1,274.6	175	44	42.7	355	44	23.9
									130	44	54.4	310	41	36.4
									209	57	51.3	29	58	45.0
									214	36	20.4	34	37	13.5
									207	15	26.9	27	16	11.2
									226	04	07.0	46	05	40.3
									267	55	46.3			
									339	43	56.8			
△ East St. Cloud School	45	33	45.56	1,406.5	94	08	48.07	1,042.4						
△ Catholic Church Spire	45	33	48.77	1,505.7	94	09	43.54	944.2						
△ Catholic Cathedral	45	33	32.90	1,015.7	94	09	44.33	961.3						
△ Standpipe	45	33	41.71	1,287.7	94	09	56.72	1,230.0						
△ Sauk Rapids School	45	35	28.56	881.7	94	09	51.71	1,121.1						

◎ Clearwater	5,430.3
◎ Cater	5,471.1
△ Clearwater Church Belfry	5,205.7
△ Clear Lake Church	
◎ Cater	6,047.4
◎ St. Augusta	7,380.9
△ St. Augusta Spire	8,930.9
△ Clearwater Church Belfry	1,550.6
△ Clearwater Church Spire	
◎ St. Augusta	7,111.4
◎ Reformatory	8,968.9
△ St. Augusta Spire	9,302.9
△ Reformatory Flagstaff	9,400.8
△ Hospital Water Tank	9,807.0
△ Clear Lake Church	
◎ Reformatory	6,671.6
◎ North Star	7,849.3
△ Hospital Water Tank	6,533.8
△ Catholic Cathedral	9,202.2
△ St. Augusta Spire	2,191.9
△ Catholic Church Spire	9,661.7
◎ North Star	5,419.9
◎ Sauk Rapids	9,540.5
△ Reformatory Flagstaff	463.2
△ Hospital Water Tank	1,235.9
△ Clear Lake Church	
△ St. Augusta Spire	
△ Catholic Spire	
△ East St. Cloud School	
◎ Sauk Rapids	7,700.3
◎ Hefnen	7,936.5
△ Catholic Church Spire	3,265.0
△ Catholic Cathedral	2,841.5
△ Standpipe	2,936.6
△ East St. Cloud School	3,935.1
△ Hospital Water Tank	
△ St. Augusta Spire	

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*—Continued.

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
Sauk Rapids	45	36	25.88	799.0	94	11	25.10	544.0	65	19	49.2	245	16	49.8	Heinen	5,987.5
									118	23	59.4	298	21	44.0	Gartner	4,666.3
									180	54	01.2	0	54	04.9	Watab	7,080.1
									311	09	17.4	131	10	24.1	Sauk Rapids School	2,688.8
									337	44	27.1				Catholic Cathedral	
									339	17	10.0				Standpipe	
									335	34	39.4				Catholic Church Spire	
Heinen	45	35	04.86	150.0	94	15	36.09	782.4	195	45	47.1	15	46	31.0	Gartner	4,904.1
									287	02	50.4	107	07	02.2	Catholic Church Spire	7,997.0
									289	11	56.2	109	15	58.6	Standpipe	7,793.3
									264	23	04.8	84	26	10.8	Sauk Rapids School	7,501.1
Gartner	45	37	37.73	1,164.8	94	14	34.59	749.2	220	54	14.1	40	56	33.2	Watab	6,433.7
									183	25	35.8	3	25	50.6	Perry	7,476.8
									308	01	05.8				Sauk Rapids School	7,313.0
Watab	45	40	15.19	469.0	94	11	19.97	432.3	124	40	08.2	304	38	03.7	Perry	4,576.7
									161	07	45.7	341	06	43.6	River Base	5,804.3
									183	52	37.0	3	52	51.2	Kipp	6,371.0
									183	05	34.0				Anderson	3,986.0
Perry	45	41	39.47	1,218.5	94	14	13.94	801.5	232	15	56.1	52	19	16.2	Church Spire	7,647.8
									213	06	49.2	33	07	51.6	River Base	3,450.5
									251	30	43.6	71	32	55.1	Anderson	4,192.0
									228	08	49.4	48	11	08.2	Kipp	5,628.7
									172	55	22.6	352	54	52.1	Skounter Hill	7,477.7
									194	08	15.6	14	09	10.7	Rice Church Spire	6,812.8
									338	01	17.7				Catholic Church Spire	
Anderson	45	42	22.49	694.3	94	11	10.15	219.5	126	46	51.9	306	45	42.7	River Base	2,609.0
									167	08	35.2	347	08	23.5	Back Base	1,582.9
									262	40	36.1				Church Spire	
River Base	45	43	13.08	403.8	94	12	46.77	1,011.5	270	36	14.4	90	37	11.9	Back Base	1,787.5
									249	27	28.9				Kipp	
									275	49	55.6				Country Church Spire	
Back Base	45	43	12.47	385.0	94	11	26.44	571.9	212	52	44.4				Kipp	1,051.3
									277	18	09.1				Church Spire	
Church Spire	45	42	46.70	1,441.7	94	06	40.33	872.2								
Kipp	45	43	41.07	1,267.9	94	11	00.05	1.1								
									125	40	04.0	305	37	14.6	Skounter Hill	6,291.6
									185	12	25.4	5	12	45.0	Gottwalt	6,513.6
									286	26	56.2	106	40	02.1	Church Spire	5,862.2
									138	27	39.4	318	26	15.7	Rice Church Spire	3,810.3
Skounter Hill	45	45	39.83	1,229.6	94	14	56.57	1,222.4	243	39	16.5	63	42	25.6	Gottwalt	6,360.9
									166	31	19.2	346	30	34.0	Royalton	5,842.0
									101	40	18.0	281	37	42.8	Sulntax	4,777.0
									287	29	07.8				Rice Church Spire	2,710.6
									119	04	07.5				North Prairie Church	
Rice Church Spire	45	45	13.43	414.6	94	12	56.95	1,230.9								

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▲ Gottwalt	45	47	11.17	344.8	94	10	32.68	706.0	112	05	16.4	292	01	22.0	▲ Royalton	7,618.3
									328	22	58.0				▲ Church Spire	9,586.5
▲ Royalton	45	48	48.83	1,353.1	94	15	59.63	1,287.3	85	06	44.1	215	04	54.1	▲ Suintax	5,764.4
									70	16	17.3	250	12	31.7	▲ North Prairie	7,222.3
									150	54	53.7	330	53	45.0	▲ Muncy	4,251.1
									139	34	35.5	319	33	32.5	▲ Royalton School	2,926.3
▲ Suintax	45	46	11.07	341.8	94	18	33.08	714.9	128	06	42.3	303	06	47.1	▲ North Prairie	4,161.6
									137	03	50.0	317	02	05.7	▲ North Prairie Church	4,612.9
									233	43	59.3				▲ Rice Spire	
▲ North Prairie	45	47	24.74	763.3	94	21	14.40	811.1	217	30	03.3	37	32	40.4	▲ Muncy	7,762.5
									169	57	07.2	349	56	14.5	▲ Hay Creek	9,084.3
									197	13	47.6	17	18	58.9	▲ North Prairie Church	1,153.6
									226	20	48.2	46	23	30.9	▲ Royalton School	6,767.1
▲ North Prairie Church	45	48	00.43	13.3	94	20	58.58	1,265.1								
▲ Royalton School	45	49	55.98	1,728.2	94	17	27.55	594.6								
▲ Muncy	45	50	44.15	1,363.0	94	17	35.40	763.3	118	52	07.8	293	48	37.9	▲ Hay Creek	6,898.4
									163	38	42.7	343	37	15.4	▲ Gregory	9,311.5
									353	29	59.6				▲ Royalton School	1,496.3
									40	58	07.4				▲ North Prairie Church	
									160	08	02.5				▲ Court-House	
▲ Hay Creek	45	52	14.46	446.4	94	22	27.89	601.6	210	54	30.7	30	56	33.3	▲ Gregory	7,164.5
									165	50	09.4	345	49	00.5	▲ Swan Creek	8,443.9
									303	23	08.1				▲ Royalton School	
									185	17	09.2				▲ Court-House	
▲ Gregory	45	55	33.52	1,084.8	94	19	37.09	799.0	109	34	46.3	289	31	35.1	▲ Swan Creek	6,097.3
									173	47	14.1	353	46	43.9	▲ Hole-in-the-day	8,352.3
									154	44	04.2	334	42	37.4	▲ Court-House	6,088.7
									157	10	33.0	337	09	17.3	▲ Schoolhouse Flagstaff	6,190.0
									344	58	56.9				▲ Royalton School	
▲ Swan Creek	45	56	39.62	1,223.2	94	24	03.81	82.1	217	39	45.3	37	42	26.9	▲ Hole-in-the-day	7,913.3
									184	24	22.1	4	24	45.2	▲ Little Elk	9,003.0
									222	12	24.1	42	14	09.1	▲ Court-House	4,678.3
									223	21	01.6	43	23	53.2	▲ Schoolhouse Flagstaff	4,959.2
▲ Court-House	45	58	31.34	983.0	94	21	37.80	313.6								
▲ Schoolhouse Flagstaff	45	58	38.30	1,182.4	94	21	28.62	616.0								
▲ Hole-in-the-day	46	00	02.47	76.3	94	20	19.10	411.0	123	14	40.7	303	12	22.2	▲ Little Elk	4,962.1
									197	19	37.3	17	20	41.4	▲ Belle Prairie	6,383.0
									31	12	01.7				▲ Court-House	3,270.7
									29	56	24.1				▲ Schoolhouse Flagstaff	2,998.3
									180	03	42.0				▲ Belle Prairie Church	3,702.5
▲ Little Elk	46	01	30.35	937.2	94	23	31.66	690.9	240	45	05.7	60	48	28.0	▲ Belle Prairie	6,923.0
									172	31	16.7	352	30	54.0	▲ Fish Lake	5,213.5
									333	29	58.4				▲ Schoolhouse Flagstaff	
									336	01	26.9				▲ Court-House	
									256	33	41.7				▲ Belle Prairie Church	
▲ Belle Prairie Church	46	02	02.38	78.5	94	20	18.91	406.7								
▲ Belle Prairie	46	03	19.81	611.7	94	18	50.66	1,089.1	104	56	48.7	284	53	03.6	▲ Fish Lake	6,952.5
									176	00	40.3	356	00	23.1	▲ Laforce	7,352.7
									88	26	51.6	218	25	48.1	▲ Belle Prairie Church	8,052.6

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*—Continued.

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
▲ Fish Lake	46	04	17.77	548.7	94	24	03.23	69.4	228	10	23.5	48	13	51.5	▲ Laforce	8,319.9
									181	54	22.8	1	54	35.3	▲ Fort Ripley	11,151.9
									310	53	51.8	130	56	33.3	△ Belle Prairie Church	6,381.9
▲ Laforce	46	07	17.37	536.3	94	19	14.49	311.1	133	53	51.1	313	50	35.3	▲ Fort Ripley	8,081.1
									183	36	15.5	3	36	38.5	▲ Vallee	10,861.4
									8	06	36.1				△ Belle Prairie Church	
▲ Fort Ripley	46	10	18.76	579.3	94	23	45.94	985.5	231	06	51.9	51	10	30.8	▲ Vallee	8,351.6
									164	21	25.8	344	20	23.6	▲ Big Mound	6,844.7
▲ Vallee	46	13	08.45	260.9	94	18	42.63	913.8	99	14	14.7	279	09	33.5	▲ Big Mound	8,454.7
									136	09	22.3	316	05	48.8	▲ Crow Wing	9,133.7
									229	10	13.7	49	13	21.1	▲ Oleson	7,340.6
									128	31	08.9				▲ Nit	12,082.1
									164	03	12.7	344	02	12.1	△ Crow Wing Church	6,535.5
▲ Big Mound	46	13	52.22	1,612.4	94	25	12.07	258.7	201	01	19.9	21	02	27.7	▲ Crow Wing	5,606.2
									169	44	15.8	349	43	38.1	▲ Nit	6,265.5
									232	58	12.5	53	01	53.2	△ Crow Wing Church	8,195.7
▲ Nit	46	17	11.89	367.1	94	26	04.22	90.3	286	35	14.5	106	37	00.1	▲ Crow Wing	3,263.3
▲ Crow Wing	46	16	41.69	1,287.3	94	23	38.14	816.5	278	29	58.0	98	36	39.0	▲ Oleson	12,015.0
									236	36	30.9	56	39	45.1	▲ Hardy	6,882.1
									278	46	47.6				△ Crow Wing Church	
△ Crow Wing Church	46	16	31.96	986.9	94	20	06.49	138.9								
▲ Oleson	46	15	43.81	1,352.8	94	14	23.28	498.5	132	18	18.1	312	14	51.1	▲ Hardy	8,283.4
									199	05	25.7	19	08	12.2	▲ Brainerd	15,033.1
									101	27	58.6				△ Crow Wing Church	
									197	12	42.2				△ Brainerd Catholic Church	
									198	17	05.7				△ Brainerd High School	
▲ Hardy	46	18	44.28	1,367.8	94	19	09.59	205.2	231	55	54.3	52	02	08.0	▲ Brainerd	14,015.7
									240	36	39.5				△ Brainerd Catholic Church	10,906.8
									244	50	27.1				△ Brainerd High School	10,410.8
									16	36	20.8				△ Crow Wing Church	
▲ Brainerd	46	23	23.84	736.1	94	10	33.17	708.8	337	51	14.5	157	52	59.4	▲ Mille Lac	8,223.6
									297	50	33.0	117	52	49.2	▲ Pegg	4,547.8
									3	19	33.2	183	19	27.4	▲ South Base	2,927.4
									312	01	04.0	132	01	57.9	▲ Rice Lake	2,140.1
									236	44	56.4	56	46	48.9	▲ Necessity	3,965.8
									204	10	40.1	24	11	52.5	▲ Parker	5,204.7
									25	03	55.4	205	03	03.3	△ Catholic Church	3,628.9
									21	01	02.2				△ Brainerd High School	4,513.4
▲ Mille Lac	46	19	17.13	528.9	94	08	08.26	176.7	50	40	03.3	230	35	32.2	▲ Oleson	10,383.7
									189	32	42.9	9	33	14.1	▲ Pegg	5,569.8
▲ Pegg	46	22	15.02	463.8	94	07	25.05	535.4	79	14	52.5	259	12	30.6	▲ South Base	4,266.1
									170	43	54.5	350	43	30.7	▲ Necessity	4,355.6
									78	12	56.5				△ Brainerd Catholic Church	

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◬ South Base	46	21	49.19	1,518.9	94	10	41.12	878.9	229	44	43.5	49	45	48.1	◬ Rice Lake	2,305.8
									177	44	10.0	357	44	07.8	◬ North Base	1,646.1
									48	17	58.4	228	17	09.4	◬ Brainerd High School	1,940.7
									75	03	55.2	255	03	08.9	◬ Brainerd Catholic Church	1,415.4
									44	02	12.0				Car Shops Chimney	
◬ Rice Lake	46	22	37.44	1,156.1	94	09	18.78	401.3	94	52	01.0	274	50	59.2	◬ North Base	1,831.3
									59	20	47.5				◬ Brainerd Catholic Church	
									49	06	09.5				◬ Brainerd High School	
◬ North Base	46	22	42.46	1,311.1	94	10	44.16	943.7								
◬ Brainerd High School	46	21	07.38	227.9	94	11	48.88	1,045.2								
◬ Brainerd Catholic Church	46	21	37.38	1,154.2	94	11	45.09	963.8								
◬ Necessity	46	24	34.24	1,057.3	94	07	57.90	1,236.5	155	18	41.2	335	18	01.0	◬ Parker	2,833.8
									225	16	35.0	45	18	33.3	◬ Snag	4,906.2
									87	43	11.2				◬ Brainerd High School	
									41	39	32.4				◬ Brainerd Catholic Church	
◬ Parker	46	25	57.60	1,778.6	94	08	53.33	1,138.6	259	20	16.6	79	22	54.9	◬ Snag	4,751.2
									222	17	07.8	42	20	19.9	◬ Cranberry	8,399.2
◬ Snag	46	26	26.01	803.1	94	05	14.60	311.7	190	28	27.8	10	29	01.3	◬ Cranberry	5,424.3
									221	18	15.1	41	20	16.7	◬ Wixon	5,419.6
◬ Cranberry	46	29	18.76	579.3	94	04	28.36	604.9	295	59	20.0	116	00	48.1	◬ Wixon	2,882.4
									243	59	08.6	64	00	37.1	◬ Rabbit	2,893.9
									166	43	35.0	346	42	58.5	◬ Camp	4,669.2
◬ Wixon	46	28	37.83	1,168.1	94	02	26.91	574.0	180	14	46.1	0	14	46.5	◬ Rabbit	2,532.3
◬ Rabbit	46	29	59.84	1,847.7	94	02	26.40	563.0	131	45	00.4	311	42	56.4	◬ Camp	4,921.0
									175	27	24.8	355	27	05.3	◬ Mission	7,237.6
									245	44	55.5	65	47	55.7	◬ Mud Lake	5,807.1
◬ Camp	46	31	45.93	1,418.2	94	05	18.66	397.6	218	09	27.5	38	11	18.0	◬ Mission	5,010.6
◬ Mission	46	33	53.50	1,652.0	94	02	53.81	1,135.3	309	27	03.9	129	30	23.8	◬ Mud Lake	7,599.9
									277	06	31.2	97	11	32.9	◬ Surre	8,919.7
◬ Mud Lake	46	31	17.01	525.2	93	58	18.00	383.7	218	44	23.2	38	46	05.0	◬ Surre	4,772.3
									270	38	32.8	90	42	03.2	◬ Dahning	6,179.0
◬ Surre	46	33	17.54	541.6	93	55	57.81	1,231.6	319	56	02.1	139	57	50.8	◬ Dahning	4,956.5
									249	05	39.4	69	08	40.2	◬ Kemres	5,675.3
◬ Dahning	46	31	14.67	453.0	93	53	28.13	599.6	199	58	29.6	19	59	41.7	◬ Kemres	6,189.6
									272	03	05.9	92	06	44.2	◬ Cedar Lake	6,417.1
◬ Kemres	46	34	23.05	711.7	93	51	48.84	1,040.2	324	36	44.6	144	39	10.9	◬ Cedar Lake	7,419.1
									252	13	24.3	72	16	35.1	◬ Pine Knoll	5,873.4
◬ Cedar Lake	46	31	07.12	219.9	93	48	27.29	581.7	189	25	44.2	9	26	28.6	◬ Pine Knoll	7,948.1
									264	51	39.4	84	56	47.0	◬ Aitkin	9,068.9
									259	18	59.4				◬ Aitkin Water Tank	7,554.3
◬ Pine Knoll	46	35	21.04	649.7	93	47	26.12	556.1	312	17	20.1	133	21	43.4	◬ Aitkin	10,447.8
									284	09	51.5	104	15	16.0	◬ Seeley	9,814.9
◬ Aitkin	46	31	33.20	1,025.1	93	41	23.49	500.6	201	11	29.2	21	12	30.4	◬ Seeley	4,961.5
									242	49	20.3	62	50	39.9	◬ Stewart	2,627.6
									208	19	57.8	28	20	35.4	◬ Upper Base	2,329.2
									169	48	35.2	349	48	23.1	◬ Lower Base	2,008.1
									131	04	28.8	311	03	47.8	◬ Church Spire	1,595.7
									110	09	41.1	290	08	46.3	◬ Water Tank	1,713.3
◬ Seeley	46	34	03.01	92.9	93	39	59.28	1,262.4	350	59	38.0	170	59	56.5	◬ Stewart	3,468.7
◬ Stewart	46	32	12.06	372.4	93	39	33.80	720.3	124	37	27.1	304	36	45.2	◬ Upper Base	1,496.9
									106	06	13.5	286	04	41.6	◬ Lower Base	2,802.5
									81	14	23.1				◬ Water Tank	

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TABLE NO. 1.—*Geographical positions north of St. Paul, Minn.*—Continued.

Station.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
ⓐ Upper Base	46	32	39.60	1,222.8	93	40	31.61	673.4	87	07	15.5	267	06	25.7	ⓐ Lower Base	1,462.6
									66	33	02.9	246	31	44.3	△ Church Spire	2,516.4
									61	44	03.4				△ Water Tank	
ⓐ Lower Base	46	32	37.21	1,149.0	93	41	40.17	855.8								
△ Aitkin Water Tank	46	31	52.32	1,615.5	93	42	38.96	830.2								
△ Lutheran Church Spire	46	32	07.15	220.8	93	42	19.94	424.9								

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TABLE No. 1 A.

DESCRIPTIONS AND APPROXIMATE ELEVATIONS ABOVE MEMPHIS DATUM OF SECONDARY TRIANGULATION STATIONS FROM ST. PAUL, MINN., TO AITKIN, MINN.

[Elevations refer to top of pipe when not otherwise specified.]

South Base: Coast and Geodetic Survey point. Copper bolt in square stone on west side of Snelling avenue. Three-fourths mile below crossing of Randolph street and Snelling avenue; 500 meters north of angle in avenue and 600 meters northeast of Quincy School in St. Paul, Minn. Elevation, ordinary levels, 1,029.36 feet.

Boshart: Tile and pipe on high knoll about 350 meters west of west line of Fort Snelling Reservation, Minn., and about 1,050 meters south of north line of same; 30 meters east of prolongation of north and south road which intersects Minnehaha avenue at Minnehaha Creek Bridge on property of David D. Stewart; NE. ¼ SE. ¼ sec. 19, T. 28, R. 23. A lone oak tree stands on southeast slope of knoll south 58.8 meters from station. Approximate elevation, 879 feet.

Prospect Park: Coast and Geodetic Survey point. A square stone post set flush with the ground on highest part of high knoll in subdivision known as Prospect Park, Minneapolis, Minn., in block east of Malcolm avenue and south of University avenue; top of stone is marked

, the center of the cross being the geodetic point. Approximate elevation of top of stone, 981 feet.

Powder Horn: Tile and pipe in southwest corner of Powder Horn Park in Minneapolis, Minn.; it is 80 feet east, 18 feet north of intersection of centers of Tenth avenue south and Thirty-fourth street. Approximate elevation, 875 feet.

Guaranty Loan Tower: Geodetic point is the round iron pole on the center of northeast (tallest) tower of Northwestern Guaranty Loan Company's building on southwest corner of Second avenue and Third street south, Minneapolis, Minn. This pole carries the wind gauge of the United States Weather Bureau. Approximate elevation of roof of tower, 1,041 feet.

Windom: Tile and pipe on east line of Silver Lake road leading northeast from the northeast corner of Windom Park in northeast Minneapolis, Minn., to northeast corner of Windom Park 33° 57′—157 meters. Approximate elevation, 963 feet.

Peck: Tile and pipe 4 meters south of north line of Thirty-sixth avenue north, about 400 meters west of river, on highest part of first high ridge from river. Pasture belonging to G. W. Peck adjoins street on the north. Blazed trees: 6-inch oak, 252°—12.8 meters; 6-inch oak, 107°—9.4 meters. Approximate elevation, 949 feet.

Mulcara: Tile and pipe on property of Thomas Mulcara, about 2 miles north of northern limits of Minneapolis, Minn., about 400 meters northeast of Mulcara's house, which is on east side of road which is the prolongation of Central avenue, on left bank of river. Station is on highest point of knoll in NW. ¼ of sec. 25, T. 30, R. 24. Blazed tree: Lone 6-inch scrub oak, 16° 3′—69 meters. Approximate elevation, 1,050 feet.

Palmer: Tile and pipe 12 meters north of south fence of east-and-west road, opposite a point 250 meters east of west end of Palmer Lake, in road passing on south side of Palmer Lake, about 2 miles west of river, and about 175 meters northeast of house, which is 2 miles north of northern limits of Minneapolis, Minn. To northwest corner of pasture=section corner $\frac{24}{25}$ | $\frac{19}{30}$, 67° 3′—43 meters. Blazed trees: 5-inch oak, 102°—5.4 meters; 6-inch oak, 217° 40′—17.2 meters. Approximate elevation, 864 feet.

Dunn: Tile and pipe on property of John Dunn, in SW. ¼ SE. ¼ sec. 26, T. 31, R. 24, 250 meters west of river road on left bank of river, about 9 miles above upper limits of Minneapolis, Minn., in oak timber, opposite first angle in road 120 meters above Dunn's (brick) schoolhouse. Blazed trees: 12-inch oak, 298°—7.4 meters; 10-inch oak, 353°—3.4 meters; 12-inch oak, 67°—3.8 meters; 8-inch oak, 143°—3.4 meters. Elevation of bolt in tile, precise levels, 884.340 feet. Elevation of cap on pipe, precise levels, 888.324 feet.

Kilmer: Tile and pipe on west side of "Middle Road," 5 miles below Champlin, Minn., 2 miles west of river, 2½ miles east and one-half mile north of Osseo, Minn., in NW. ¼ SW. ¼ sec. 8, T. 119, R. 21. Station is about 50 meters southeast of large red barn and directly in front of house of Charles Kilmer. To blazed 16-inch oak, 143°—9.2 meters. Approximate elevation, 884 feet.

Powell: Tile and pipe on south side of river road about 3¼ miles below Anoka, Minn., on left bank of river, on section line between secs. 16 and 21, T. 31, R. 24, on line between property of George Smith and Lewis Greenwald, 2 meters north of south road fence, directly south of residence of S. J. Powell, one-half mile below District School No. 2. Blazed trees: 10-inch scrub oak, 101°—12.5 meters; 24-inch scrub oak, 352° 25′—12.3 meters. Elevation of bolt in tile, precise levels, 874.579 feet; elevation of cap on pipe, precise levels, 878.566 feet.

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△ Howard: Tile and pipe on high knoll on south side of farm road, one-fourth mile west of main road between Champlin and Osseo, about 2 miles below Champlin, Minn., 22.6 meters west of northwest corner of pasture, on property of A. D. Howard, NE. ¼ NE. ¼ sec. 31, T. 120, R. 21. Approximate elevation, 928 feet.

△ Carvel: Tile and pipe on high ground in cultivated field about 1 mile northwest of Anoka, Minn., on property of R. D. Carvel, in NW. ¼ SW. ¼ sec. 36, T. 32, R. 25, 400 meters north of Great Northern Railway, 500 meters west of north-and-south State road, 250 meters north of residence of B. Nye, and 8.1 meters east of southeast corner of small vacant house used as a granary. Blazed trees: 24-inch double oak, 190°—10.8 meters; 10-inch double oak, 137°—8.4 meters. Approximate elevation, 897 feet.

△ Johnson: Tile and pipe near west end of high ridge in meadow land on property of Frank A. Johnson, in section 18, about 180 meters south of Hassan road, one-fourth mile above its junction with river road on right bank 3 miles above Champlin, Minn. Station is 200 meters southwest of Johnson's house and 14 meters east of corner of cultivated field. Approximate elevation, 942.5 feet.

△ Carpenter: Tile and pipe on west side of north-and-south road, 1 mile north of Anoka and Elk River road, on highest part of ridge, about 700 meters north of L. J. Carpenter's residence, on section line between secs. 21 and 22, T. 32, R. 25. Mrs. Rogers owns property east and L. J. Carpenter west of road. This north-and-south road joins river road about 3 miles above Anoka, Minn. To southwest corner of pasture fence 187° 53′—107.6 meters. Approximate elevation, 905 feet.

△ Diegel: Tile and pipe 1 meter south and 1 meter west of junction of fences (northeast and west) in edge of meadow land, on property of Frank Diegel, in NW. ¼ SE. ¼ sec. 6, T. 120, R. 22, three-fourths of a mile south of Dayton, Minn, one-half mile east of Dayton and Shakopee road, and one-half mile west of right bank river road. Clearing is northwest and cultivated field northeast of station. Approximate elevation, 939 feet.

△ Clark: Tile and pipe 15 meters west and 4 meters south of fence corner at southeast corner of cultivated field, in edge of pasture, on property of G. M. Clark, on quarter-section line of N. ¼ sec. 18, T. 32, R. 25. Station is about 1¼ miles north of Itasca railroad station, one-half mile east of county line between Anoka and Sherburne counties, and about 1,000 meters northeast of George Clark's house. Approximate elevation, 911 feet.

△ Carrow: Tile and pipe in edge of timber on high ridge, about 1 mile above Dayton, Minn., about 300 meters back of right bank river road, directly opposite head of Dayton Island, 2 meters west of north-and-south fence between timber and cultivated field, 75 meters south of south fence of wagon road, on property of Gasper Carrow, in sec. 25, T. 121, R. 26. Approximate elevation, 943 feet.

△ Castle: Tile and pipe on property of Castle and Houlton, in SW. ¼ SE. ¼ sec. 2, T. 32, R. 26, about 2 miles below Elk River, Minn., one-half mile back of Northern Pacific Railway, on high gravel knoll in scrub-oak timber. This knoll is the southwestern one of a series of high knolls and ridges. Station is 17 meters east of north-and-south fence, 75 meters north of junction of fences at edge of cultivated field. Blazed trees: 6-inch scrub oak, 77°—8.3 meters; 6-inch scrub oak, 263°—8 meters; 8-inch scrub oak, 13° 45′—15.3 meters. Approximate elevation, 949 feet.

△ Fritz: Tile and pipe 2.3 meters north of east-and-west fence on section line between secs. 16 and 21, T. 121, R. 23, 2 miles southwest of Elk River, Minn., in scattering scrub-oak timber and grass, on property of Fred Johanning, about 600 meters west of point where wagon road between Otsego and Dayton turns northwest off the section line, and 57 meters west of junction of fences at edge of cultivated field. Approximate elevation, 896.5 feet.

△ Elk River: Tile and pipe in scattering scrub-oak timber, about 1¼ miles northwest of Elk River, Minn., 32 meters east of east right-of-way fence of the Milaca branch of Great Northern Railway, on south end of ridge, 120 meters north of east-and-west wagon road, on property of Albert Nicholson, in SE. ¼ NW. ¼ sec. 28, T. 33, R. 26. Approximate elevation, 971.5 feet.

△ Davis Island: Tile and pipe on left bank of river, three-fourths of a mile above Otsego ferry landing, 100 meters below a point opposite foot of Davis Island, on property of E. E. Scott, sec. 6, T. 32, R. 26 W., 2 meters from crest of sand ridge, 20 meters below sharp turn at upper end of ridge. Approximate elevation, 916 feet.

△ Williams: Tile and pipe on north side of wagon road between Elk River and Big Lake, Minn., 5 miles above Elk River, 1¼ miles from river bank, one-half meter south of north line of road, 35 meters east of prolongation of east side W. K. Williams's residence, in SE. ¼ sec. 26, T. 33, R. 27. Approximate elevation, 934 feet.

△ Baker: Tile and pipe 2 meters back of crest of bluff on right bank of river, about 3 miles above Otsego, Minn., directly opposite head of Demicks Island, one-half mile north and one-half mile east of Lily Pond schoolhouse, in growth of young poplar, oak, and brush, on property of N. E. Baker, in sec. 11, T. 121, R. 24; 6-inch blazed oak is 2 meters toward river from station. Approximate elevation, 969 feet.

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Ⓐ Varley: Tile and pipe about 1½ miles below Big Lake, Minn., 7.4 meters south of south right-of-way fence of Northern Pacific and Great Northern railways, on fence on east line of Christopher Varley's property, between cultivated field on west and woods pasture on east, in sec. 28, T. 33, R. 27. Approximate elevation, 942 feet.

Ⓐ East Base (Monticello Base Line): Tile and pipe in east and west public road, on north side of river, about 1 mile below a point opposite lower limits of Monticello, Minn., 1 meter south of fence on north line of road. Adjoining property belongs to Mr. McAllester. Elevation of bolt in tile, precise levels, 938.646 feet. Elevation of cap on pipe, precise levels, 942.630 feet.

Ⓐ West Base (Monticello Base Line): Tile and pipe in east and west public road, on north side of river, opposite lower end of Monticello, Minn., about 200 meters below turn in road at river bank, 1 meter south of fence on north side of road. Adjoining property belongs to Mr. Taft. Elevation of bolt in tile, precise levels, 938.268 feet. Elevation of cap on pipe, precise levels, 942.229 feet.

Ⓐ Lambert: Tile and pipe on property of Mrs. Lambert, near section line between secs. 16 and 17, T. 121, R. 24, on high wooded knoll covered with second-growth poplar and brush and a few scattering large oaks, about one-half mile from river bank, 4 miles below Monticello, Minn. Station is on east slope of knoll, 2 meters west of north and south wire fence, about 400 meters southwest of new yellow house and 200 meters northwest of two small ponds. Blazed trees: 30-inch double oak, 70° 40′—27.7 meters; 24-inch oak, 36° 15′—42.7 meters. Approximate elevation, 1,018 feet.

Ⓐ Telephone: Tile and pipe 1 meter north of southeast fence of Monticello and Big Lake road, about one-half mile from Big Lake, Minn., 56.7 meters northeast of junction of north and south fence with road fence, on second ridge from Monticello, which crosses road, and about 300 meters west of timber. Approximate elevation, 953 feet.

Ⓐ Big Lake: Tile and pipe 1½ meters north of south right-of-way fence of Great Northern and Northern Pacific railways, 1½ miles above Big Lake, Minn., 19 meters west of center of farm road which crosses railroads about the center of long curve. Approximate elevation, 958 feet.

Ⓐ Monticello: Tile and pipe on top of small bluff back of upper end of Monticello, Minn., about one-half mile west of depot at Monticello, about 80 meters above where southwest wagon road crosses low bluff, on north side of row of cottonwood trees, and 25 meters north of an old house. Blazed trees: 12-inch cottonwood, 345° (magnetic)—5 meters; 12-inch cottonwood, 43° (magnetic)—5 meters. Approximate elevation, 971 feet.

Ⓐ Shenton: Tile and pipe on north fence line of east and west wagon road, about 4½ miles above Big Lake, Minn., 600 meters southwest of Great Northern and Northern Pacific railways, one-half mile west of schoolhouse at Salida siding, on top of small ridge, on property line of Mr. Shenton in NW. ¼ sec. 16. Approximate elevation, 979 feet.

Ⓐ Becker: Tile and pipe in Becker and Big Lake wagon road, which runs parallel and adjacent to railroad tracks, one-half mile below Becker, Minn., 300 meters below road crossing, 81.1 meters below junction of road fence with east and west fence, and 1½ meters from fence on northeast side of wagon road. Approximate elevation, 980 feet.

Ⓐ Ackerman: Tile and pipe about 7 miles above Monticello, Minn., one-half mile back of Clearwater and Monticello road, opposite a large cultivated field adjacent to road on river side, on quarter-section line, 150 meters east of section line between secs. 23 and 24, T. 122, R. 26, at south edge of timber, about 30 meters back of road through timber on line between property of Mr. Nelson on the north and Mrs. Ackerman on the south. Blazed trees: 6-inch oak, 265°—6 meters 8-inch oak, 180°—8 meters. Approximate elevation 1,032 feet.

Ⓐ River Bank: Tile and pipe 120 meters back from right bank of river, 10 miles above Monticello, Minn., 100 meters north of Monticello and Clearwater wagon road, on high sand ridge in scrub-oak timber, where river makes a sharp bend to the north, near lower end of low marshy ground along river (evidently old river bed), opposite a point 150 meters above where wagon road enters timber and approaches in sight of river, on property of Mr. Clark in sec. 16, T. 122, R. 26. Blazed trees: 10-inch scrub oak, 195° 25′—17.8 meters; 8-inch scrub oak, 358°—7.4 meters; 8-inch scrub oak, 64° 25′—22.9 meters. Approximate elevation, 1,003 feet.

Ⓐ Parks: Tile and pipe on west side of lane, 1 meter east of fence, on line of east and west fence, about 3 miles northwest of Becker, Minn., three-fourths of a mile north of Becker and Clearwater road, and 600 meters north of Mr. Park's residence. Lane is on section line between secs. 26 and 27, T. 34, R. 29. Approximate elevation, 988 feet.

Ⓐ Benson: Tile and pipe about 3½ miles below Clearwater, Minn., 10 meters back from right bank of river, on lower side of old cut-off, about 100 meters south of end of boom across mouth of cut-off, about 40 meters south of row of bulldog piers, 2

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meters west of fence, on property of Walter Benson, in sec. 7, T. 122, R. 29. Blazed tree: 30-inch white oak —7.6 meters. Approximate elevation, 994 feet.

Ⓐ Clear Lake: Tile and pipe in lower end of Clear Lake village, about 400 meters east of Northern Pacific Railway station, on property of James Brooks, and 80 meters east of his residence, in northeast corner of pasture lot, 3 meters south and 1½ meters west of fence intersection, on south side of Clear Lake and Becker wagon road, which is on south side of railroad tracks and contains telephone line. Approximate elevation, 1,005 feet.

Ⓐ Clearwater: Tile and pipe in oak timber, 15 meters back from right bank of river, 1 mile above Clearwater, Minn., about 200 meters west of northwest corner of cultivated field, which reaches within 50 meters of river bank, near lower end of sharp bend to the left in river and 20 meters north of prolongation of right bank of reach below, on property of P. A. Leme, in NW. ¼ SE. ¼ sec. 27, T. 123, R. 27. Blazed trees: 8-inch white oak, 309°—3.8 meters; 12-inch white oak, 103°—3.4 meters; 6-inch white oak, 212°—4.8 meters. Approximate elevation, 1,008 feet.

Ⓐ Cater: Tile and pipe in scrub-oak timber, on high and very prominent mound, about 200 meters northeast of Clear Lake and St. Cloud wagon road, which contains telephone line, about 9 miles below St. Cloud and 3½ miles above Clear Lake, on property of D. A. Cater, in sec. 35, T. 35, R. 30, about 25 meters from front and 15 meters from upper slope of mound. Approximate elevation, 1,052 feet.

Ⓐ St. Augusta: Tile and pipe in scrub oak timber, 5 meters back from right bank of river, 150 meters above northwest corner of cultivated field on river bank, about 1½ miles northeast of St. Augusta church, 5 miles below St. Cloud, Minn., 250 meters below mouth of Johnson Creek, directly on line of white schoolhouse 1 mile from left bank of river and State Reformatory stack; on property of V. L. Wilson, in SW. ¼ NE. ¼ sec. 7, T. 123, R. 27. Blazed trees: 6-inch scrub oak, 353°—3.8 meters; 8-inch scrub oak, 103°—3.7 meters. Approximate elevation, 1,023 feet.

Ⓐ Reformatory: Tile and pipe about 3 miles southeast of St. Cloud, Minn., 500 meters southeast of State Reformatory, on highest point on east side of bluffs, between heads of second and third draws below the one up which wagon road turns, in scattering scrub-oak timber, on State property, in SE. ¼ NE. ¼ sec. 7, T. 35, R. 30. Blazed trees: 5-inch scrub oak, 256°—13.7 meters; 5-inch scrub oak, 313°—14.8 meters; 5-inch scrub oak, 16°—9.2 meters; 4-inch scrub oak, 92°—13.2 meters. Approximate elevation, 1,110 feet.

Ⓐ North Star: Tile and pipe 1½ miles southwest of St. Cloud, Minn., on top of highest ridge, one-half meter west of north and south fence on west side of North Star Cemetery, on property of Margaret Brady, in sec. 22, T. 124, R. 28. Blazed trees: 8-inch red oak, 160°—6.7 meters; 8-inch red oak, 9°—7.3 meters; 8-inch red oak, 263°—6.1 meters. Approximate elevation, 1,169 feet.

Ⓐ Heinen: Tile and pipe about 5½ miles northwest of St. Cloud, Minn., on township line between St. Cloud and St. Joseph townships and about 250 meters south of their north line, at south end of rail fence, at junction of south and west roads, 75 meters north of farm residence of Mathias Heinen, and 18 meters north of north side of barn. Approximate elevation, 1,075 feet.

Ⓐ Sauk Rapids: Tile and pipe on west side of abandoned north and south road, which turns to right over bluff from river road 1½ miles above Sauk Rapids, Minn., about 20 meters back of crest of bluff, opposite a point about 150 meters above lower end of cultivated field on river bank, one-fourth of a mile below crossing of river road over railroad, near center of sec. 15. Blazed trees: 10-inch black oak, 221°—14 meters; 8-inch black oak, 100°—13.7 meters. Approximate elevation, 1,096 feet.

Ⓐ Gartner: Tile and pipe on right bank of river about 7 miles above St. Cloud, Minn., 1½ meters west of east side of public road, which is the third wagon road west of river, 50 meters above a point opposite farmhouse of Peter Gartner, on line between secs. 19 and 20, T. 125, R. 28, and about 400 meters south of section corner. Blazed trees: 15-inch oak, 125°—15.1 meters; 24-inch oak, 60°—13.4 meters; 13-inch oak, 344°—6.5 meters. Approximate elevation, 1,066 feet.

Ⓐ Watab: Copper bolt leaded vertically in solid rock on extreme south end of large granite mound known as Little Rock, which is between left bank river road and the river, just below mouth of Little Rock River, and about 8 miles above St. Cloud, Minn. Station is about 3 meters from south end of highest part of ridge. Approximate elevation of copper bolt, 1,105 feet.

Ⓐ Perry: Tile and pipe on right bank of river, about 10 miles above St. Cloud, Minn., about 1 mile west of Brockaway Schoolhouse No. 7, three-fourths of a mile northwest of farm buildings on Clark's upper farm, on property of J. N. Perry, on east edge of high ridge, in oak timber, about 250 meters below southeast corner of cultivated field on ridge. Blazed trees: 12-inch oak, 349° 30′ —17.4 meters; 12-inch oak, 146° 30′ —24.1 meters. Approximate elevation, 1,139 feet.

Ⓐ Anderson: Tile and pipe on east side of sand hill, in scattering scrub-oak trees, about 3 miles southeast of Rice, Minn., 400 meters southwest of farmhouse of Mr.

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Anderson, on property of Taylor and Calhoun, about 50 meters north of land line between grass and cultivated fields, in SW. ¼ of sec. 10. Blazed trees: 14-inch oak, 314°—4.3 meters; 8-inch oak, 253°—7 meters; 8-inch oak, 178°—11.3 meters. Approximate elevation, 1,061 feet.

Back Base (Rice Base Line): Tile and pipe in open prairie, 300 feet west of Northern Pacific Railway, 2 miles south of Rice's Station, about 10 meters south of section line. Elevation of bolt in tile, precise levels, 1,063.141 feet. Elevation of cap on pipe, precise levels, 1,067.120 feet.

River Base (Rice Base Line): Tile and pipe on left bank of river in public road, about 2 miles below Rice, Minn., about one-half mile above ferry, and 8 meters below section line. Elevation of bolt in tile, precise levels, 1,059.545 feet. Elevation of cap on pipe, precise levels, 1,063.524 feet.

Kipp: Tile and pipe on sand mound 1¼ miles east of river, 2½ miles southeast of Rice, Minn., one-half mile west of Little Rock Lake, one-half mile northeast of point where north and south road crosses railroad, on line with church spire in eastern horizon and house on bank of lake, on property of Mr. Kipp, in SW. ¼ of sec. 3. Approximate elevation, 1,063 feet.

Skounter Hill: Tile and pipe on large bare sand mound, 1½ miles northwest of Rice, Minn., on highest part of mound, on property of Deering Manufacturing Company, of St. Paul. Mound is only one of size in vicinity and is known as Skounter Hill. Approximate elevation, 1,112 feet.

Gottwalt: Tile and pipe near center of north and south road, 5 meters east of wagon track, midway between houses of Joseph Culeger and Lewis E. Gottwalt, one-half mile north of road leading northeast from Rice, Minn., about 3 miles from Rice, on first road branching to left after passing Rice Mill. Approximate elevation, 1,091 feet.

Suintax: Tile and pipe on highest point of very high and prominent ridge, 6 miles below Royalton Bridge over Mississippi River, 1½ miles back from right bank of river, on narrow projecting ridge between two small draws, 200 meters west of house, on north and south road 500 meters south of junction with east and west road, near center of sec. 34, T. 127, R. 29, and one-half mile south of county line: 10-inch blazed burr oak, 149°—10.2 meters. Approximate elevation, 1,257 feet.

Royalton: Tile and pipe in scrub-oak timber on ridge 600 meters east of Northern Pacific Railway, 1½ miles below Royalton, Minn., 350 meters north of east and west wagon road, 30 meters west of edge of wheat field, about 250 meters west and 40 meters south of farmhouse, on property of S. G. Hillman, in E. ½ SW. ¼ sec. 1, T. 38, R. 32. Blazed trees: 8-inch scrub oak, 136°—15.7 meters; 10-inch scrub oak, 246°—5.6 meters; 8-inch black oak, 3°—7.2 meters. Approximate elevation, 1,148 feet.

North Prairie: Tile and pipe three-fourths of a mile south of North Prairie Church on north and south fence line, 47 meters north of east and west wagon road, on property of J. Gamrath, in SE. ¼ SW. ¼, sec. 20, T. 127, R. 29, on line between cultivated field on west and timber on east. Approximate elevation, 1,175 feet.

Muncy: Tile and pipe 120 meters northeast of wagon bridge just below dam across Platte River, three-fourths of a mile above Royalton, Minn., on ridge in oak timber, 5 meters east of north and south fence, 43 meters south of junction of fences, on property of G. W. Muncy. Blazed trees: 10-inch red oak, 358°—16.9 meters; 8-inch red oak, 273°—15 meters; 10-inch red oak, 163°—4.2 meters. Approximate elevation, 1,132 feet.

Hay Creek: Tile and pipe on high ridge, one-half mile west of river road on right bank, about 8 miles below Little Falls, Minn., on line between cultivated field on east and brush on west, on property of A. Trofas, about 300 meters west of farmhouse, about opposite middle of field. Farm road to above house branches to northwest from river road at an old dilapidated house and barn. Approximate elevation, 1,167 feet.

Gregory: Tile and pipe on top of high ridge 3 miles below Little Falls, Minn., three-fourths of a mile northwest of Gregory siding on Northern Pacific Railway, 350 meters back of end of ridge, 9 meters south of wire fence, 5 meters west of 4-foot bowlder, on property of F. P. Farrow, in NW. ¼ sec. 34, T. 128, R. 32. Approximate elevation, 1,236 feet.

Swan Creek: Tile and pipe on high ridge on right bank of river, about 3 miles below Little Falls, Minn., 1 mile below mouth of Swan Creek and one-half mile west of river, 2 meters south of east and west fence and 65 meters west of junction with north and south fence, in timber, on property of Wiecoent Rekocoski, 300 meters northeast of group of three houses which stand on second east and west road below Swan Creek, and 150 meters nearly south of large lone pine. Blazed trees: 24-inch white oak, 264°—17.4 meters; 20-inch white oak, 161° 30'—23.1 meters; 10-inch red oak, 45°—3.4 meters. Approximate elevation, 1,237 feet.

Hole-in-the-day: Tile and pipe on highest knoll on Hole-in-the-day Bluff (so called from Indian chief whose grave is thereon), 1¼ miles northeast of Little Falls

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court-house, due east of a point 100 meters north of grand stand at race track, in brush on upper side of bluff, S. 45° E.—300 meters from farmhouse on prairie above. Approximate elevation, 1,260 feet.

△ Little Elk: Tile and pipe on high ridge on upper side of Little Elk River, about 2½ miles above Little Falls, Minn., 400 meters north of Little Elk River, 1½ miles west of Mississippi River, opposite upper end of marshy ground north of ridge. Ridge is 20 feet higher 200 meters east of station. First well-traveled road branching to left from river road above Little Elk River passes 200 meters north of station. Blazed trees: 8-inch pine, 286°—9.3 meters; 10-inch pine, 38°—6.9 meters; 8-inch pine, 168°—18.1 meters. Approximate elevation, 1,216 feet.

△ Belle Prairie: Tile and pipe on south side of east and west wagon road, 70 meters west of north and south wagon road, three-fourths of a mile east of river, and 1 mile northeast of Belle Prairie Church. Approximate elevation, 1,152 feet.

△ Fish Lake: Tile and pipe on front end of high ridge north of west end of Fish Lake, 8 miles northwest of Little Falls and 1½ miles west of Green Prairie post-office, at edge of grove of pine trees. Road leading west from Green Prairie post-office, branches on bank of lake. The right-hand road passes 40 meters south of station. Approximate elevation, 1,225 feet.

△ Laforce: Tile and pipe on prominent bare knoll, 3 miles below Fort Ripley post-office, three-fourths of a mile back of front range of hills, on western end of a very narrow east and west gravel ridge between cultivated fields, one-half mile west of north and south road, on property of Peter Laforce and one-half mile south of his residence. Approximate elevation, 1,269 feet.

△ Fort Ripley: Tile and pipe on right bank of river, 1 mile west of blockhouses at old Fort Ripley, near center of large concave bend in crest of bluff, 5 meters from crest of bluff, at lower side of grove of black oak trees and about 50 meters east of mouth of large ravine. Approximate elevation, 1,335 feet.

△ Big Mound: Tile and pipe about 4 miles above old Fort Ripley, on right bank 1½ miles from river, 400 meters north of second road above Fort Ripley Ferry, branching to left from river road, about 1½ miles east of Mrs. Brown's residence, on top of largest mound in vicinity, which is the largest mound east of Chadwick Lake. A small log cabin stands at junction of above road with river road. Approximate elevation, 1,451 feet.

△ Vallee: Tile and pipe on small knoll on top of large brush-covered ridge, about 3 miles northwest of Lenox siding, one half mile north of Clute Schoolhouse, district No. 8, on property of Louis Vallee, 50 meters west of north and south wire fence and 400 meters west of Fort Ripley and St. Mathias wagon road. Approximate elevation, 1,321 feet.

△ Crow Wing: Tile and pipe on highest part of isolated ridge, about 2 miles below Crow Wing River, 3 miles back from Mississippi River, on right bank, 1 mile north of first road below Crow Wing River leading west, 1½ miles northwest of schoolhouse, 150 meters west of road crossing ridge to small shanty on upper side of hill, opposite east end of large open lake, which terminates in a tamarack swamp extending around west end and along north side of ridge. Approximate elevation, 1,310 feet.

△ Oleson: Tile and pipe about one-fourth of a mile southeast of farmhouse of Chris Oleson, on Brainerd and St. Mathias wagon road, 3 miles northeast of Crow Wing depot and about 3 miles below point where this road crosses railroad, in jack pines, 80 meters east of north and south wire fence on upper end of last high ridge in vicinity, on property of Northern Pacific Railway Company, in S. ½ sec. 27. Blazed trees: 6-inch red oak, 346°—5 meters; 14-inch jack pine, 143°—3.3 meters; 12-inch jack pine, 236°—13.7 meters. Approximate elevation, 1,310 feet.

△ Hardy: Tile and pipe on extreme upper end of brush-covered ridge, 8 miles southwest of Brainerd, Minn., on highest and most prominent ridge in vicinity, 1½ miles back from right bank of river, 600 meters southwest from Island Lake, 600 meters southeast of farm residence of John W. Roberts, on property of Park Hardy, in NW. ¼ sec. 22, T. 133, R. 29. Approximate elevation, 1,291 feet.

△ Brainerd: Tile and pipe on highest point on Ahrends Hill, which is a very conspicuous hill on right bank of river, one-half mile above sawmill in North Brainerd and 2 miles above city of Brainerd; station is at end of wagon road which branches to west from river road and leads to summit of the hill. Blazed trees: 24-inch black oak, 194°—33.2 meters; 12-inch black oak, 125°—20.4 meters. Approximate elevation, 1,359 feet.

△ Mille Lac: Tile and pipe 5 miles southeast of Brainerd, Minn., 4 meters south of Mille Lac wagon road, three-fourths of a mile south and three-fourths of a mile east of county poorhouse, 103 meters west of a 9-inch double red-oak tree at roadside, and beside which is a 3-foot bowlder. Line to △ Brainerd on prominent hill above Brainerd passes about 50 meters to the right of poorhouse. Scattering trees, brush, and grass surround station. Blazed trees: 10-inch red oak, 177° 25′—34.2 meters; double red oak, 309°—102.7 meters. Approximate elevation, 1,289 feet.

△ Pegg: Tile and pipe 3 miles east of sawmill in North Brainerd, 400 meters south

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of Deerwood and Brainerd wagon road, in grass and brush on ridge, 400 meters southeast of residence of Enoch Jennings, on property of Mr. Pegg, about 80 meters southeast of fence corner, and 5 meters south of a 20-inch black-oak tree. Approximate elevation, 1,276 feet.

Rice Lake: Tile and pipe on brush-covered ridge on east side of Rice Lake, directly east of sawmill, 3 miles above Brainerd, Minn.; about 300 meters from bank of lake or bay, on ridge between roads, one being old road along bank of lake and the other the Aitkin river road. Blazed tree: 6-inch red oak, 327°—2.9 meters. Approximate elevation, 1,279.5 feet.

South Base (Brainerd base line): Tile and pipe on south side of jack-pine grove, 20 meters from edge of high ground, and on prolongation of north and south street (Mill street), leading south from sawmill, in northeast Brainerd. Supposed to be in alley of a newly surveyed addition, about 20 feet east of line of ditch running south across meadow lands. Blazed trees: 8 inch jack pine, 188°—11.2 meters; 6-inch jack pine, 261°—15.1 meters. Elevation of bolt in tile, precise levels, 1,219.914 feet. Elevation of cap on pipe, precise levels, 1,223.891 feet.

North Base (Brainerd base line): Tile and pipe in center of Mill street, in northeast Brainerd, about 150 meters from left bank of river, 11 meters nearly south of switch block on Brainerd and Northern Minnesota Railway, 40 meters northeast of road crossing, and opposite east and west roadway through Brainerd Lumber Company's lumber yard. Elevation of bolt in tile, precise levels, 1,211.057 feet. Elevation of cap on pipe, precise levels, 1,215.039 feet.

Necessity: Tile and pipe on east end of very high partly timbered ridge, about 4 miles above upper part of Brainerd, Minn., about 1 mile from river on left bank, on homestead of Henry Grossman, in sec. 4, T. 45, R. 30, one-half mile northeast of farm residence of John Leckshiedt. Road nearest to river passes at foot of ridge, about 200 meters east of station. Approximate elevation, 1,337 feet.

Parker: Tile and pipe on high wooded knoll covered with jack-pine trees and oak and poplar brush, 5 miles above Brainerd, Minn., 400 meters west of Solomon Markee's house, on right bank of river, on highest ground, 200 meters west of crest of bluff and near largest pine on the hill. Land on which station stands belongs to Solomon Markee. Blazed tree: 12-inch jack pine, 138°—7.4 meters. Approximate elevation, 1,311 feet.

Snag: Tile and pipe one-half mile south of river, on left bank of river, 9 miles above Brainerd, Minn., 1¼ miles below mouth of Rabbit River, on highest mound in vicinity, about 300 meters northeast of Rabit Lake wagon road. A 50-foot dead-pine snag shows very conspicuously on same mound. To snag, 60° 14′—41.6 meters. Approximate elevation, 1,367 feet.

Cranberry: Tile and pipe on high ridge about 1 mile east of river, 600 meters east of Cranberry Lake, 1 mile northwest of Anderson's house, in N. ¼ sec. 12, about 2 miles above mouth of Rabbit River and 14 miles above Brainerd, Minn. Hill is bare, except small brush and grass, and is about 400 meters north of a deep hollow containing marsh and pond. Approximate elevation, 1,324 feet.

Wixon: Tile and pipe on timbered ridge on south bank of Rabbit River, 300 meters west of Rabbit Lake road three-fourths of a mile below where it crosses Rabbit River at ford, on property of Phelander Wixon and one-fourth of a mile northwest of his residence, near northwest corner and on north line of sec. 8, T. 46, R. 27, on ridge at end of bay formed by backwater up Rabbit River, 200 meters northeast of a lone clump of pines. Blazed trees: 6-inch black oak, 61°—16.2 meters; 8-inch poplar, 205°—9.2 meters. Approximate elevation, 1,271 feet.

Rabbit: Tile and pipe on knoll covered with short brush, otherwise bare with exception of 8 small Norway pines on east end, 200 meters west of Rabbit Lake road, 1 mile above upper Rabbit River ford. The wagon road forks about one-half mile above ford, the left one passing near station, which is on first bare knoll west of road. Blazed tree: 14-inch Norway pine, 313° 18′—49.7 meters. Approximate elevation, 1,303 feet.

Camp: Tile and pipe one-half mile northwest of Dr. Camp's house, which is on right bank of river and was formerly an old Indian mission, on State land, on east side of wagon road at gate, one-half mile east of Mission Lake, 2 meters north of junction of east, west, and south fences at northwest corner of pasture. Approximate elevation, 1,210.5 feet.

Mission: Tile and pipe on Mission Ridge, a high ridge one-half mile north of upper end of Mission Lake, one-half mile below mouth of Pine River, 600 meters west of Mississippi River, on rocky knoll, at head of large ravine running toward river, among scattering Norway pines, 200 meters west of thick pine grove and 16 meters northwest of large bowlder. Blazed trees: 12-inch Norway pine, 90°—4 meters; 10-inch Norway pine, 134°—19.5 meters. Approximate elevation, 1,330.5 feet.

Mud Lake: Tile and pipe about 2 miles back from left bank of river, opposite foot of Rabbit Lake, on west end of southwest or last knoll or ridge of a series of knolls and ridges below Mud Lake. To reach station, take the trail that leaves

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wagon road at lower end of pass between Mud and Rabbit lakes at log shanty; follow around foot of Mud Lake and go about one-half mile southwest of next log shanty. Blazed trees: 6-inch black oak, 94°—7.6 meters; 8-inch black oak, 275°—2.9 meters. Approximate elevation, 1,326 feet.

Ⓐ Surre: Tile and pipe about 15 miles below Aitkin, Minn., on knoll in timber, about 600 meters back from right bank of river, opposite a small shanty on river bank in bend of Tow Head Rapids, and on property of Mr. Surre. An Indian trail leaves road leading back from shanty, about 300 meters from river, and goes directly to station. Blazed trees: 12-inch poplar, 112°—6.6 meters; 12-inch black oak, 198°—14.2 meters; 30-inch red oak, 258°—18.3 meters. Approximate elevation, 1,290 feet.

Ⓐ Dahning: Tile and pipe 4 miles west of Cedar Lake, Minn., 1 mile west of large white schoolhouse on timbered ridge, on property of Fred Dahning and one-half mile southwest of his house, in Sec. 28, T. 47, R. 28, opposite head of Rabbit Lake. Wagon road branching from Deerwood and Aitkin road 1 mile below Cedar Lake passes Dahning's house and turns south around foot of ridge 300 meters from station. Blazed trees: 24-inch red oak, 315°—26.3 meters; 10-inch red oak, 35°—11 meters; 8-inch red oak, 127°—21.3 meters. Approximate elevation, 1,352.5 feet.

Ⓐ Kemres: Title and pipe 8 miles below Aitkin, Minn., about 200 meters from left bank of river, on property of G. Kemres and one-fourth of a mile below his residence, in SW. ¼ NE. ¼ sec. 10, one-fourth of a mile below an abandoned ferry at mouth of Deans Brook, 50 meters north of wagon road, and 25 meters east of north and south fence. Blazed trees: White pine, 289°—14 meters; white pine, 353°—17.7 meters; Norway pine, 72°—4 meters. Approximate elevation, 1,219 feet.

Ⓐ Cedar Lake: Tile and pipe 40 meters northwest of creamery in lower end of Cedar Lake, Minn., at south side of wagon road, 15 meters west and 3 meters north of fence corner. Wagon road is main road leading northwest from town. Approximate elevation, 1,232 feet.

Ⓐ Pine Knoll: Tile and pipe 5 miles below Aitkin, Minn., about 80 meters from right bank of river, on property of James Welton, three-fourths of a mile below his present residence and near the site of his proposed residence, in sec. 13, T. 136, R. 25, one-fourth of a mile below Indian Wigwam, on lower side of bend in river, where general course of river changes from north to southwest, in section of country known as Pine Knoll. Blazed trees: 18-inch white pine, 22°—19.2 meters; 36-inch white pine, 199°—2 meters. Approximate elevation, 1,216 feet.

Ⓐ Aitkin: Tile and pipe 1 mile southeast of Aitkin, Minn., 8 meters south of center of road which runs parallel to Northern Pacific Railway, one-half mile south of railroad, 70 meters west of point where road forks on east and west half-section line one-fourth of a mile west of range line, in sec. 25, T. 47, R. 27. Blazed trees: 10-inch red oak, 138° 15′—33 meters; 10-inch red oak, 46°—16.6 meters; 9-inch poplar, 4° 15′—25 meters. Approximate elevation, 1,277 feet.

Ⓐ Seeley: Tile and pipe 3 miles northeast of Aitkin, Minn., 300 meters back from left bank of river, 200 meters south of Seeley Schoolhouse, which stands at corner of road, 2 meters west of east fence of wagon road, on north and south section line, between secs. 7 and 8, T. 47, R. 26. Approximate elevation, 1,211 feet.

Ⓐ Stewart: Tile and pipe on railroad property 2½ miles east of Aitkin, Minn., 500 meters east of residence of Mr. Stewart, 300 meters north of Northern Pacific Railway track, in deadening, 50 meters east of junction of two old logging roads, on south branch of road. Approximate elevation, 1,259 feet.

Ⓐ Upper Base (Aitkin base line): Tile and pipe 1½ miles above Aitkin, Minn., at angle in public road, 1½ meters west of east fence of north and south road, on half-section line, in sec. 19, T. 47, R. 26, one-fourth of a mile south of section line, 5 meters north of fence intersection, at angle in road, and on line with north ditch in east and west wagon road. Elevation of cap on pipe, ordinary levels, 1,215.38 feet.

Ⓐ Lower Base (Aitkin base line): Tile and pipe about 20 meters back from left bank of river, about 1,500 meters above wagon bridge over Mississippi River at Aitkin, Minn., at extreme lower end of point of timber, on line with east and west road, 650 meters west of angle in road, at township line, one-fourth of a mile south of section line between secs. 13 and 24, T. 47, R. 27. Elevation of bolt in tile, precise levels, 1,205.271 feet. Elevation of cap on pipe, precise levels, 1,209.252 feet.

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TABLE NO. 2.—*Geographical positions of stone line benchmarks north of St. Paul, Minn.*

[Referred to the Cairo Astronomical Post.]

Number of benchmark.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
⊡ 284	44	56	53.59	1,654.2	93	11	58.82	1,289.4	90	59	20	270	59	08	⊡ 284	394.0
									122	17	10				△ City Hall	
									132	53	50				Tower	
⊡ 285	44	56	53.81	1,661.0	93	12	16.80	868.3	251	42	50				Club House Dome	
									320	38	46				Convent Chimney	
⊡ 286	44	58	46.70	1,441.5	93	14	31.97	700.5	20	35	45	200	35	40	⊡ 285	422.3
									82	59	55				△ City Hall	
									121	32	23				△ Exposition Building	
⊡ 286	44	58	33.90	1,046.4	93	14	38.75	849.1								
⊡ 287	45	01	00.54	16.7	93	16	24.30	532.0	88	42	48	268	42	35	⊡ 286	431.4
									111	28	17	291	27	45	◬ Peck	1,075.0
									61	33	49				Engine House Tower	
									166	22	45				Water Tank	
									228	09	41				Pv. Elevator Chimney	
⊡ 288	45	01	00.23	7.1	93	16	44.00	963.4	203	21	06				Water Tank	
									260	04	46				Shoreham Elevator Chimney	
									243	49	02				Pv. Elevator Chimney	
⊡ 287	45	03	39.43	1,217.3	93	16	54.32	1,188.4	264	00	42	84	02	24	◬ Mulcara	3,178.3
									4	23	16	184	23	05	◬ Peck	4,523.4
									100	09	35	280	09	24	⊡ 287	352.0
									345	25	44				Pv. Elevator Chimney	
									346	54	32				Exposition Building	
									1	19	39				Engine House Tower	
⊡ 287	45	03	41.44	1,279.4	93	17	10.15	222.1	265	36	08				◬ Mulcara	
									341	34	48				Pv. Elevator Chimney	
									344	46	11				Exposition Building	
⊡ 288	45	05	50.88	1,570.8	93	16	34.68	758.2	93	56	18	273	55	53	⊡ 288	792.2
									87	16	22				Church Spire	
									118	36	42				Gable of House	
⊡ 289	45	05	52.64	1,625.1	93	17	10.83	236.7	85	10	28				Church Spire	
									8	21	30				Barn Cupola	
⊡ 290	45	08	51.89	1,602.0	93	18	30.96	676.4	310	34	21	130	34	55	◬ Dunn	1,386.8
									46	33	42	226	33	25	⊡ 289	695.0
									325	35	18				Windmill	
									46	09	45				Chimney of House	
⊡ 291	45	08	36.41	1,124.1	93	18	54.06	1,181.1	285	13	24	105	14	15	◬ Dunn	1,614.8
									119	52	22				Gable of Red Barn	
⊡ 270	45	10	06.90	213.0	93	21	01.79	39.1	59	55	33	239	55	19	⊡ 270	519.6
									137	08	51				Mill Flagstaff	
									140	10	08				Anoka Catholic Church	

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TABLE NO. 2.—*Geographical positions of stone line benchmarks north of St. Paul, Minn.*—Continued.

Number of bench mark.	Latitude.			Seconds.	Longitude.			Seconds.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″	*Meters.*	°	′	″	*Meters.*	°	′	″	°	′	″		*Meters.*
⊡ $^{2}\frac{7}{3}^{0}$	45	09	58.46	1,804.8	93	21	22.38	488.8	262	00	48				ⓐ Powell	
									138	37	08				Southeast Corner of House	
⊡ $^{2}\frac{7}{2}^{1}$	45	11	42.19	1,302.5	93	24	01.05	22.9	21	36	23	201	36	20	⊡ $^{2}\frac{7}{1}^{1}$	314.6
									319	11	30				Pt. of West Bridge Pier	
									321	28	35				Telegraph Pole on West Span	
⊡ $^{2}\frac{7}{3}^{1}$	45	11	32.72	1,010.2	93	24	06.35	138.6	231	07	49				Mill Flagstaff	
									239	34	09				Anoka Catholic Church	
									242	17	32				Anoka Congregational Church	
⊡ $^{2}\frac{7}{2}^{2}$	45	13	29.04	896.5	93	26	36.14	788.6	27	33	35	207	33	04	ⓐ Johnson	2,105.0
									8	08	13	188	03	09	⊡ $^{2}\frac{7}{3}^{2}$	1,017.8
									287	01	23				Northwest Corner Yellow House	
									119	59	27				Gable of White House	
⊡ $^{2}\frac{8}{2}^{2}$	45	12	56.40	1,741.2	93	26	42.68	931.3	197	35	02				Gable of White House	
									221	00	52				Schoolhouse Flagstaff	
⊡ $^{2}\frac{8}{3}^{3}$	45	14	31.57	974.6	93	29	37.88	826.1	30	25	47	210	25	39	⊡ $^{2}\frac{7}{3}^{3}$	1,047.6
									261	48	12	81	50	04	ⓐ Carpenter	3,482.7
									41	18	32				ⓐ Diegel	2,020.4
									93	17	57				Dayton Church Spire	
									293	37	37				Anoka Standpipe	
⊡ $^{2}\frac{8}{2}^{3}$	45	14	02.31	71.3	93	30	02.20	48.0	293	25	53				Anoka Catholic Church	
									294	09	43				Mill Flagstaff	
									132	15	03				Dayton Church Spire	
⊡ $^{2}\frac{8}{3}^{4}$	45	15	58.55	1,807.6	93	32	47.77	1,041.4	54	24	24	234	24	09	⊡ $^{2}\frac{7}{3}^{4}$	578.8
									206	29	34				Schoolhouse Flagstaff	
									274	39	24				Gable of House	
⊡ $^{2}\frac{8}{3}^{4}$	45	15	47.63	1,470.4	93	33	09.36	204.0	323	47	15				ⓐ Carrow	
									328	29	27				Gable of House	
									209	04	29				Cupola of Barn	
									146	00	49				Cupola	
⊡ $^{2}\frac{8}{1}^{6}$	45	18	06.55	202.2	93	33	43.57	949.3	106	58	24	286	57	45	Elk River School	1,229.3
									56	49	22	236	49	13	⊡ $^{2}\frac{7}{1}^{6}$	313.9
									310	59	53				ⓐ Castle	
									151	07	05				Church Spire	
⊡ $^{2}\frac{8}{1}^{8}$	45	18	00.98	30.2	93	33	55.62	1,211.8	192	43	57				Church Spire	
⊡ $^{2}\frac{7}{2}^{6}$	45	17	41.75	1,288.9	93	36	40.39	880.0	100	19	42	280	19	15	ⓐ Davis Island	866.0
									6	53	59	186	53	58	⊡ $^{2}\frac{7}{1}^{6}$	441.4
									7	05	07				Church Spire	
⊡ $^{2}\frac{8}{1}^{6}$	45	17	27.55	850.5	93	36	42.82	983.2	126	36	27	306	36	01	ⓐ Davis Island	995.2
									7	51	25				Church Spire	
⊡ $^{2}\frac{8}{1}^{7}$	45	18	00.41	12.6	93	40	33.98	740.3	354	03	51	174	03	52	ⓐ Baker	449.1
									10	46	30	190	46	28	⊡ $^{2}\frac{7}{1}^{7}$	335.9
⊡ $^{2}\frac{8}{1}^{7}$	45	17	49.72	1,535.0	93	40	36.87	803.3	316	53	58				ⓐ Baker	
									121	57	41				Gable of House	

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⊡ 2[19]	45	18	25.53	783.2	93	43	41.84	911.6	286	25	52	106	28	07	△ Baker	4,315.9
									356	42	34	176	42	35	⊡ 2[18]	903.7
									351	25	54				△ Lambert	1,660.6
									100	59	01				Barn Cupola	
⊡ 2[18]	45	17	56.80	1,738.1	93	43	39.45	859.5	345	11	34				△ Lambert	
									72	36	56				Chimney on House	
⊡ 2[17]	45	18	20.61	636.3	93	46	47.32	1,031.0	307	26	11	127	26	20	△ West Base	316.9
									39	44	28	219	44	20	⊡ 2[13]	421.6
									230	55	33				△ Telephone	
									223	26	33				Big Lake Church Spire	
⊡ 2[12]	45	18	10.11	312.1	93	46	59.69	1,300.5	141	00	55				Water Tank	
									19	55	45				House Cupola	
⊡ 2[10]	45	19	51.15	1,579.1	93	49	11.92	259.6	54	56	39	234	56	22	⊡ 2[10]	635.6
									155	49	07				△ Shenton	
									327	28	21				Schoolhouse	
⊡ 2[9]	45	19	39.38	1,214.2	93	49	35.81	779.8	243	34	50				Southeast Corner of House	
⊡ 2[11]	45	21	09.75	301.0	93	52	15.14	329.6	265	25	00	85	26	32	△ Shenton	2,807.0
									16	23	08	196	22	57	⊡ 2[11]	1,175.2
									173	40	37				Becker Spire (new)	
									175	40	03				Becker Spire (white)	
⊡ 2[11]	45	20	33.23	1,025.9	93	52	30.37	661.1	263	23	59				Cupola of Red Barn	
⊡ 2[8]	45	22	54.80	1,691.8	93	54	20.77	451.8	54	57	39	234	57	10	⊡ 2[8]	1,071.1
									6	59	19	186	59	08	△ Ackerman	2,582.7
									261	30	44				△ Becker	3,122.8
									238	08	14				Church Spire	
⊡ 2[8]	45	22	34.87	1,076.5	93	55	01.08	23.5	197	29	48				Gable of House	
									160	39	43				Corner of Barn Cupola	
⊡ 2[8]	45	24	00.90	27.8	93	57	10.57	229.9	242	28	33	62	29	51	△ Parks	2,673.5
									2	04	46	183	04	43	△ River Bank	2,768.9
									260	16	42				Gable of House (red roof)	
									114	30	57				Gable of Yellow House	
⊡ 2[8]	45	23	46.24	1,427.5	93	57	22.54	490.4	340	55	10	160	55	15	△ River Bank	489.1
⊡ 2[4]	45	24	50.57	1,561.2	94	00	23.20	504.5	316	25	21	136	27	35	△ River Bank	5,934.6
									353	32	36	173	32	44	△ Benson	2,071.5
									102	04	52				Clearwater Church Spire	
									187	43	34				Clear Lake Church Spire	
⊡ 2[4]	45	24	16.91	522.0	94	00	19.77	430.0	351	10	14	171	10	19	△ Benson	1,031.4
									40	25	45				Pole on Barn	
									57	26	07				Barn Cupola	
⊡ 2[5]	45	25	31.98	987.3	94	02	42.06	914.3	68	06	34	248	06	21	⊡ 2[5]	444.2
									35	13	06				Corner of Church Belfry	
⊡ 2[5]	45	25	26.62	821.8	94	03	01.02	22 2	343	08	24				Church Spire	
⊡ 2[3]	45	26	57.17	1,765.0	94	04	50.41	1,095.5	276	13	11	96	16	56	△ Clear Lake	6,900.1
									321	12	05	141	12	56	△ Clearwater	2,493.8
									50	04	30	230	04	16	⊡ 2[3]	549.5
									66	17	06				Lone Oak Tree	
									74	47	39				Lone Oak Tree	
⊡ 2[2]	45	26	45.74	1,412.1	94	05	09.80	213.0	101	45	33	281	45	02	⊡ 2[2]	950.9
⊡ 2[1]	45	29	05.53	170.7	94	06	25.93	563.2	71	11	39	251	10	55	△ St. Augusta	1,414.6
									80	43	16				St. Augusta Spire	
									164	01	26				St. Raphael Hospital Tank	
									222	34	33				Country Church Spire	

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TABLE NO. 2.—*Geographical positions of stone line benchmarks north of St. Paul, Minn.*—Continued.

Number of bench mark.	Latitude.	Seconds.	Longitude.	Seconds.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″	*Meters.*	° ′ ″	*Meters.*	° ′ ″	° ′ ″		*Meters.*
⊡ $2\frac{12}{}$	45 29 11.81	364.6	94 07 06.79	190.9	273 44 49	93 48 29	◬ Cater	6,714.6
					32 07 31	212 07 18	◬ St. Augusta	767.4
					73 28 41		St. Augusta Spire	
					232 02 58		Country Church Spire	
					172 10 39		St. Raphael Hospital Tank	
⊡ $2\frac{13}{}$	45 31 22.05	680.7	94 08 18.58	403.2	59 00 28	239 00 11	⊡ $2\frac{13}{}$	614.6
					116 05 43	296 03 49	◬ North Star	2,869.4
					200 54 43		St. Raphael Hospital Tank	
					284 32 19		Country Church Spire	
⊡ $2\frac{14}{}$	45 31 11.80	364.3	94 08 42.85	980.0	209 38 58		St. Raphael Hospital Tank	
					176 20 54		Normal Flagstaff	
⊡ $2\frac{15}{}$	45 33 38.17	1,178.4	94 08 56.92	1,234.4	73 30 35	253 30 26	⊡ $2\frac{29}{}$	272.0
					355 16 22		Normal Flagstaff	
					107 56 23		Catholic Church Spire	
⊡ $2\frac{16}{}$	45 33 35.66	1,100.9	94 09 08.95	194.1	235 59 13	55 59 28	East St. Cloud School	546.4
⊡ $2\frac{17}{}$	45 35 53.87	1,663.1	94 11 00.46	10.0	61 59 47	241 59 36	⊡ $2\frac{30}{}$	382.7
					233 14 50		Northeast Corner of Mill	
					74 59 30		Gable of House	
⊡ $2\frac{18}{}$	45 35 48.05	1,483.4	94 11 16.05	347.8	170 28 07	350 28 01	◬ Sauk Rapids	1,184.4
					119 37 20		Gable of House	
⊡ $2\frac{1}{}$	45 38 21.57	665.9	94 12 06.21	134.5	85 23 45	265 23 34	⊡ $2\frac{21}{}$	330.0
					186 37 50		Gable of House	
⊡ $2\frac{21}{}$	45 38 20.71	639.4	94 12 21.40	463.5	217 07 27		Gable of Barn	
⊡ $2\frac{2}{}$	45 40 03.37	104.0	94 11 24.94	589.8	196 25 31		◬ Watab	380.4
					84 19 29	264 19 02	⊡ $2\frac{22}{}$	317.7
⊡ $2\frac{22}{}$	45 40 00.75	23.2	94 12 02.52	54.5	136 59 45	316 58 11	◬ Perry	4,168.8
					244 10 26		◬ Watab	1,023.4
					128 12 45		Gable of House	
⊡ $2\frac{23}{}$	45 41 51.96	1,604.1	94 12 26.96	583.3	73 29 51	253 29 35	⊡ $2\frac{3}{}$	513.7
					80 33 26		◬ Perry	
					110 43 16		Cupola of Barn	
⊡ $2\frac{24}{}$	45 41 47.23	1,458.1	94 12 49.73	1,075.9	82 31 00	262 30 00	◬ Perry	1,837.6
					148 56 34		Barn Cupola	
					357 52 12		School Flagstaff	
⊡ $2\frac{25}{}$	45 43 46.51	1,435.9	94 12 53.01	1,146.2	299 17 47	119 18 49	◬ Back Base	2,146.6
					24 57 46	204 57 39	⊡ $2\frac{24}{}$	490.2
					273 55 06		◬ Kipp	2,448.2
					282 51 50		Church Spire	
					178 10 19		Rice Spire	
⊡ $2\frac{26}{}$	45 43 32.12	991.6	94 13 02.58	55.8				
⊡ $2\frac{27}{}$	45 45 14.16	437.2	94 15 31.22	674.9	223 22 55	43 23 20	◬ Skounter Hill	1,090.2
					103 16 53	283 16 29	⊡ $2\frac{28}{}$	761.7
					270 22 40		Rice Spire	
⊡ $2\frac{28}{}$	45 45 19.33	612.2	94 16 05.52	119.3	247 29 21		◬ Skounter Hill	1,613.0

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⊡ 218	45	47	06.19	191.1	94	17	42.52	918.5
⊡ 219	45	46	54.28	1,675.8	94	17	57.23	1,236.3
⊡ 217	45	48	44.64	1,378.1	94	20	10.03	216.5
⊡ 222	45	48	29.05	896.8	94	20	30.98	669.1
⊡ 223	45	50	45.22	1,396.0	94	20	38.88	838.9
⊡ 224	45	50	26.24	810.1	94	21	29.60	638.9
⊡ 225	45	53	00.26	8.0	94	21	26.60	573.6
⊡ 226	45	52	56.75	1,752.0	94	21	37.79	814.9
⊡ 227	45	55	26.80	827.4	94	22	44.57	960.5
⊡ 229	45	55	25.93	800.5	94	23	04.72	101.7
⊡ 231	45	57	46.30	1,429.4	94	23	27.78	598.1
⊡ 232	45	57	46.57	1,437.7	94	23	04.65	100.1
⊡ 233	45	59	55.85	1,724.2	94	21	17.38	374.0
⊡ 234	45	59	56.93	1,757.6	94	22	01.21	26.0
⊡ 235	46	02	08.47	107.1	94	20	15.97	343.5
⊡ 236	46	02	01.53	47.2	94	20	59.59	1,281.5
⊡ 237	46	04	12.25	378.2	94	19	42.53	914.1
⊡ 238	46	03	56.52	1,745.2	94	20	26.23	563.7
⊡ 239	46	06	14.50	447.7	94	20	28.31	608.1
⊡ 241	46	06	01.14	35.2	94	21	05.71	122.6
⊡ 242	46	08	18.89	583.3	94	22	02.70	58.0
⊡ 243	46	08	19.48	601.5	94	22	49.04	1,052.8

40	49	46	220	49	36	⊡ 226	486.1
32	41	56				△ Suintax	
42	11	56				Gable of House	
30	08	38	210	08	12	△ Suintax	1,542.5
43	14	02	223	13	47	⊡ 227	660.5
270	14	18	90	17	17	△ Royalton	5,406.4
29	24	32	209	23	46	△ North Prairie	2,831.4
37	31	54				Church Spire	
34	00	01				Church Spire	
301	50	42	121	54	03	△ Royalton	7,097.6
61	50	13	241	49	37	⊡ 228	1,241.5
270	27	40	90	29	52	△ Muncy	3,959.3
296	10	46				Catholic Spire	
81	16	07				South Gable of House	
65	48	32	245	48	24	⊡ 229	264.5
115	43	33				Chimney, East Wing of House	
140	36	32				Gable of House	
86	27	57	266	27	42	⊡ 230	434.9
267	02	24				△ Gregory	
261	57	07				Southwest Corner of House	
90	36	56	270	36	30	⊡ 231	794.0
217	25	26				Court-house	
250	44	27				Catholic Hospital	
254	04	40				Catholic School	
240	07	54				Church Spire	
92	01	11	272	00	39	⊡ 232	943.8
260	44	48				△ Hole-in-the-Day	
358	08	54				Brewery	
9	37	13				Court-house	
265	32	24	85	33	38	△ Hole-in-the-Day	2,204.0
187	33	31				Water Tank	
185	34	47				Gable of Barn Cupola	
217	52	56	37	53	57	△ Belle Prairie	2,986.6
86	20	52	266	20	21	⊡ 233	939.9
62	00	42				Belle Prairie Church	71.1
268	16	15				Belle Prairie Church	
325	26	40	145	27	18	△ Belle Prairie	1,965.7
62	39	57	242	39	26	⊡ 234	1,057.2
91	46	00				△ Fish Lake	5,605.2
338	26	36				Gable of House	
249	48	39				Southwest Corner of House	
62	48	02	242	47	35	⊡ 235	903.0
24	37	49				Chimney on White House	
15	26	29				Schoolhouse Flagstaff	
225	24	31				△ Laforce	3,353.4
350	45	55				Schoolhouse Flagstaff	
91	02	28	271	01	54	⊡ 236	994.8
7	30	37				Gable of Barn	
192	11	55				Windmill	
352	41	55				Snag on Bluff	

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TABLE NO. 2.—*Geographical positions of stone line benchmarks north of St. Paul, Minn.*—Continued.

Number of benchmark.	Latitude.	Seconds.	Longitude.	Seconds.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″	*Meters.*	° ′ ″	*Meters.*	° ′ ″	° ′ ″		*Meters.*
⊡ 28Z	46 10 48.64	1,501.9	94 21 46.38	994.7	70 49 10	250 48 59	⊡ 28Z	341.1
					70 13 30		⛰ Fort Ripley	2,725.6
					356 08 21		Schoolhouse Flagstaff	
					6 38 00		Gable of House	
⊡ 28Y	46 10 45.01	1,389.8	94 22 01.40	30.0				
⊡ 28	46 12 48.30	1,491.4	94 23 40.82	875.0	99 23 46	279 23 41	⊡ 28	167.2
					151 36 02		Lone Pine (½ mile above)	
⊡ 29	46 12 49.19	1,518.9	94 23 48.51	1,039.8	160 50 18		Lone Pine (½ mile above)	
⊡ 29	46 14 43.98	1,358.0	94 21 49.35	1,057.1	306 22 49	126 25 04	△ Vallee	4,970.8
					150 53 35	330 53 25	⊡ 30	592.5
					69 49 10		△ Big Mound	4,628.1
					129 56 59		△ Nit	
					225 26 27		East Gable of House	
⊡ 29	46 15 00.75	23.2	94 22 02.80	60.0	62 27 49	242 25 32	△ Big Mound	4,573.8
⊡ 30	46 16 45.02	1,390.1	94 20 16.91	362.0	152 40 10	332 40 00	⊡ 30	598.5
					331 03 34	151 03 41	Old Crow Wing Church	460.7
⊡ 30	46 17 02.24	69.2	94 20 29.74	636.7	331 58 10		Old Crow Wing Church	
⊡ 31	46 18 14.17	437.5	94 17 58.93	1,261.2	151 16 50	331 16 47	⊡ 31	190.1
					82 31 42		Snag (½ mile below)	
⊡ 31	46 18 19.57	604.3	94 18 03.19	68.3	326 20 27		Chimney on House	
					63 43 47		Snag (½ mile below)	
⊡ 31	46 19 19.61	605.5	94 14 50.49	1,080.2	145 08 06	325 08 02	⊡ 32	210.4
⊡ 32	46 19 25.20	778.1	94 14 56.11	1,200.4	299 44 52		Lower Piling	
⊡ 33	46 21 01.93	59.6	94 12 18.92	404.5	80 36 21	260 36 08	⊡ 33	390.2
					255 18 58	75 19 19	Schoolhouse Belfry	663.8
					197 34 32		Engine House	
⊡ 33	46 20 59.87	1,848.7	94 12 36.92	789.5	257 15 53		Schoolhouse Belfry	
					223 42 21		Catholic Church	
⊡ 34	46 22 47.52	1,467.3	94 10 41.85	894.3	17 32 47	197 32 45	△ North Base	163.8
					132 06 19	312 06 10	⊡ 34	344.1
					24 52 10		Schoolhouse Belfry	
⊡ 34	46 22 54.99	1,698.0	94 10 53.80	1,184.2	284 55 50	104 56 59	△ Rice Lake	2,101.7
					331 57 32		△ North Base	438.2
					19 30 49		Schoolhouse Belfry	
					24 34 49		Catholic Church	
⊡ 35	46 25 08.79	271.4	94 08 36.38	777.0	98 04 03	278 03 50	⊡ 35	379.0
					166 30 04	346 29 52	△ Parker	1,550.1
⊡ 35	46 25 10.51	324.5	94 08 53.95	1,152.2	180 31 53		△ Parker	
⊡ 35	46 26 24.72	763.3	94 06 28.15	601.0	139 37 10	319 36 56	⊡ 36	635.0
					74 53 56	254 52 11	△ Parker	3,210.3
⊡ 36	46 26 40.38	1,246.8	94 06 47.43	1,012.3	63 50 25	243 48 54	△ Parker	2,994.7
					282 36 34		△ Snag	
⊡ 37	46 27 56.43	1,742.4	94 04 13.44	286.7	109 10 09	289 10 01	⊡ 37	259.8
⊡ 37	46 27 59.19	1,827.7	94 04 24.94	532.1				

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TABLE NO. 3.—*Comparisons of cross-section elements, Soot Bluffs, Louisiana, to Donaldsonville, La., surveys of 1895–96 and 1897–98.*

AT LOW WATER.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at low water.		Average maximum depth at low water.	
		1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	828.7										
85	830.5	8.2	10.3	2,245	2,213	115,883	125,386	51.1	56.3	94.2	99.8
86	835	8.8	10.3	2,474	2,483	95,171	100,454	39	41.1	61.2	63.7
87	839.6	9.1	10.4	2,676	2,683	93,230	94,162	35.8	36.2	69.3	73.1
88	842.9	9.1	10 7	2,485	2,541	101,104	110,935	45.5	49.2	96.7	105.1
89	846.5	8.4	10	2,525	2,583	101,637	102,560	40.4	39.9	64.8	64.7
90	849.8	8.5	9.8	2,399	2,329	107,879	110,578	46.8	49.9	97	105.8
91	851.5	8.1	9.6	2.784	2,714	106,255	112,433	39.9	42.4	65.8	78.4
92	857.5	7.3	9.5	2,359	2,342	104,669	122,462	47.1	55.7	97.2	116.2
93	861.3	8	9.8	2,861	2,860	105,265	112,583	38.1	41.2	69.7	75.3
94	864	8	10	2,334	2,341	118,798	128,482	52.9	57.2	95.3	105.5
95	866	8.2	10.4	2,674	2,716	111,952	117,169	42.4	41	65.4	70.7
96	870.6	8.4	10.5	2,470	2,498	109,201	119,906	47	52	97.5	108.7
97	872.8	8.4	10.7	2,598	2,650	111,605	114,483	43.5	43.8	59.1	65.7
98	877	8.6	10.5	2,449	2,445	108,239	114,000	46.5	49	89.7	97.4
99	879.6	9.2	10.6	2,686	2,689	113,433	109,583	42.4	40.7	60.9	63
100	882.3	9.2	10.6	2,323	2,263	130,038	146,138	57.6	66.9	97.2	114.8
101	885.3	8.7	10.6	2,331	2,388	137,954	148,066	60.7	63.3	104.2	114.1

NOTE.—The averages in the following tables are derived from a larger number of sections than those previously published. The stretches are derived by separating the river into lengths covering the alternate pools and crossings.

The low-water plane used in these tables coincides with the stage of 1895–96 as given in column 3.

AT MEDIUM STAGE.

No. of stretch.	Distance from Cairo.	Average stage (above Memphis datum) of—			Average width of cross sections.		Average area of cross sections.		Average mean depth at medium stage.	
		Medium stage.	When sounded.							
			1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*
	828.7									
85	830.5	29.3	8.2	10.3	2,523	2,463	165,848	175,395	65.2	70.9
86	835	28.9	8.8	10.3	2,703	2,700	146,005	151,252	54.5	56.3
87	839.6	27.9	9.1	10.4	3,323	3,356	148,969	149,589	45.4	45.2
88	842.9	27.4	9.1	10.7	2,983	2,993	151,978	162,174	53.4	57.2
89	846.5	26.9	8.4	10	2,737	2,791	149,847	151,796	54.7	54.6
90	849.8	26.5	8.5	9.8	2,932	2,871	155,995	157,662	54.8	56.7
91	851.5	26.2	8.1	9.6	3,041	3,048	158,336	163,436	53.4	54.8
92	857.5	25.7	7.3	9.5	2,621	2,653	148,203	165,977	57.9	65.1
93	861.3	25.3	8	9.8	3,055	3,075	155,029	163,618	51.9	54.7
94	864	24.9	8	10	2,575	2,555	160,081	169,461	63.5	68.1
95	866	24.7	8.2	10.4	2,855	2,868	157,143	154,143	55.8	54.4
96	870.6	24.4	8.4	10.5	3,001	2,925	153,295	162,718	53.7	59.3
97	872.8	24	8.4	10.7	2,775	2,817	158,504	156,843	56	56.3
98	877	23.7	8.6	10.5	2,936	2,990	150,109	156,072	52.7	54.9
99	879.6	23.4	9.2	10.6	2,910	2,890	152,040	147,523	52.3	51.1
100	882.3	23.1	9.2	10.6	2,631	2,466	163,340	179,240	64.3	75.2
101	885.3	22.8	8.7	10.6	2,583	2,567	172,764	175,208	67.9	72.2

NOTE.—The medium stage used in these tables corresponds to the mean of the highest and lowest water of 1882. (See Report M. R. C., 1890, p. 3129.)

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TABLE NO. 3.—*Comparisons of cross-section elements, Scot Bluffs, Louisiana, to Donaldsonville, La., surveys of 1895–96 and 1897–98*—Continued.

AT BANK-FULL STAGE.

No. of stretch.	Distance from Cairo.	Average stage (above Memphis datum) of—			Average width of cross sections.		Average area of cross sections.		Average mean depth at bank-full stage.	
		Bank-full stage.	When sounded.							
			1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet*	*Feet.*	*Feet.*
	828.7									
85	830.5	40	8.2	10.3	2,671	2,627	193,254	202,335	71.7	76.7
86	835	40	8.8	10.3	2,826	2,827	176,477	182,496	63	64.8
87	839.6	38.3	9.1	10.4	3,513	3,521	184,613	184,759	52.7	52.9
88	842.9	40	9.1	10.7	3,170	3,192	189,596	201,645	61.5	64.9
89	846.5	38	8.4	10	2,876	2,900	181,381	183,325	63.5	63
90	849.8	38	8.5	9.8	3,115	3,105	190,094	191,280	62.1	63.3
91	851.5	38	8.1	9.6	3,220	3,227	194,402	199,273	61.6	63.1
92	857.5	36.7	7.3	9.5	2,807	2,867	177,929	196,084	64.6	69.8
93	861.3	35.2	8	9.8	3,222	3,221	186,015	194,386	58.7	61.6
94	864	35	8	10	2,833	2,784	187,318	196,002	66.6	71
95	866	35	8.2	10.4	2,971	2,979	188,242	184,901	63.5	62.6
96	870.6	34.5	8.4	10.5	3,155	3,185	184,866	193,808	61.2	63.8
97	872.8	33.4	8.4	10.7	2,879	2,929	179,555	183,132	62.9	63.3
98	877	33	8.6	10.5	3,223	3,294	177,951	184,183	57.3	58.5
99	879.6	33	9.2	10.6	3,054	3,092	180,492	176,080	59	57.2
100	882.3	33	9.2	10.6	2,898	2,742	191,359	204,320	67.4	76.7
101	885.3	33	8.7	10.6	2,794	2,729	199,733	209,425	72.9	78.4

NOTE.—The bank-stage used in these tables corresponds to the elevation of the top of bank at each section.

TABLE NO. 3 A.—*Comparison of cross-section elements, Donaldsonville, La., to Carrollton, La., surveys of 1893–94 and 1897–98.*

AT LOW WATER.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at low water.		Average maximum depth at low water.	
		1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	889										
1	890.5	23.2	10.6	3,113	3,086	115,032	114,084	37	37	72.8	78.7
2	891.8	22	10.5	2,456	2,486	166,752	158,964	69.8	67	119.7	114.2
3	892.8	21.8	10.4	2,251	2,176	131,046	141,114	58.5	65.4	98.8	105.5
4	895	19.7	11.3	2,148	2,146	148,824	150,144	69.7	70.4	127.3	124.9
5	898.1	17.5	11.7	1,976	1,968	121,703	119,613	61.7	60.9	93.4	91.7
6	900.1	16.5	11.9	1,977	1,945	129,160	125,663	66.1	64.3	123.9	119.5
7	901	16	12.3	1,974	1,946	139,543	138,011	71.1	71.2	106.3	106.9
8	903	15.8	12.3	1,931	1,945	135,240	139,012	70.8	71.9	116.2	114.8
9	906.1	15.5	12.6	2,321	2,306	120,939	122,735	52.2	53.3	77.9	77.6
10	909	15.4	12.5	2,280	2,248	144,724	151,467	64.2	68.2	108.4	117.2
11	910.5	15.3	12.5	2,758	2,730	125,356	120,804	45.4	44.3	72.1	78.2
12	912.1	15.2	12.2	2,449	2,448	125,804	130,300	51.9	54	115.4	120
13	912.8	15.1	11.7	2,189	2,176	147,629	153,931	68	71.6	102	106.7
14	914.3	14.8	11.5	2,077	2,065	134,296	141,500	65.1	69.1	98.1	106.1
15	917.7	14.2	11.3	2,230	2,216	127,135	130,575	57.4	59	81.9	83.3
16	919.5	13.7	10.8	2,307	2,302	122,680	130,380	53.3	56.8	97.7	102.4
17	920.7	13.4	10.7	2,378	2,328	132,564	136,760	56.1	59.6	89.9	93.4
18	922.2	13.1	10.8	2,548	2,439	219,044	210,695	89	86.7	131.2	137.4
19	923.3	12.9	10.7	2,308	2,307	138,124	137,022	60	59.5	92.4	90.5
20	926	12.8	10.5	2,195	2,192	131,208	137,320	60	62.8	107.7	113.8
21	927.1	12.6	10.2	2,037	2,024	126,474	130,543	62.3	64.7	86.4	90.6
22	928.6	12.5	10.4	1,793	1,771	128,148	134,728	71.8	76.3	117.4	124.2
23	930.1	12.5	10.4	2,555	2,523	138,240	141,188	54.1	56.2	80.8	84.2
24	931.1	12.4	11.6	2,879	2,858	143,395	151,925	49.8	53	87.9	89.2
25	932.7	12.2	11.8	2,422	2,361	105,828	110,604	43.8	46.9	63.9	67.2
26	935.8	12	11.9	2,226	2,189	150,127	150,190	67.3	68.4	112.2	114.1
27	937.4	11.8	12.8	2,169	2,118	125,440	129,196	57.8	61	84.7	88
28	938.6	11.8	12.8	2,187	2,169	123,749	136,577	56.6	62.3	97.8	108.1
29	939.7	11.7	13.2	2,729	2,619	119,526	127,543	43.9	48.9	79.4	83.7
30	942.4	11.7	14.3	2,452	2,403	204,975	207,697	82.8	85.5	138.1	143.5
31	944.5	11	15.8	2,225	2,213	131,280	130,006	59.3	58.8	88.9	92.6
32	946.2	10.6	16	2,019	2,010	132,190	134,453	66	67.4	105.4	109.2
33	948.2	10.5	16.7	2,375	2,353	137,470	140,697	58.3	60.1	90	89.4

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TABLE No. 3 A.—*Comparison of cross-section elements, Donaldsonville, La., to Carrollton, La., surveys of 1893–94 and 1897–98*—Continued.

AT LOW WATER—Continued.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at low water.		Average maximum depth at low water.	
		1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
34	952.4	9.8	17.1	2,488	2,457	130,293	132,746	51.3	55.3	98.9	98.1
35	953.7	9.1	17.4	1,889	1,868	142,529	147,395	75.8	78.4	114.5	114.3
36	957.3	9.1	17.6	2,400	2,364	140,084	140,706	60.8	61.4	101.9	99.8
37	958.7	9	17.8	2,496	2,456	138,152	145,728	54.9	59.2	84	90.6
38	960.3	9	18	2,341	2,349	181,263	189,055	79.1	82.1	133.1	136
39	961.7	8.9	17.9	2,377	2,370	143,738	141,604	60.7	59.9	97.3	93.3

NOTE.—The distances from Cairo given in these tables are taken from the latest published maps.
The stretches are derived by separating the river into lengths covering the alternate pools and crossings.
The low-water plane used in these tables is 7.3 feet above Memphis datum.

AT BANK-FULL STAGE.

No. of stretch.	Distance from Cairo.	Average stage (above Memphis Datum) of—			Average width of cross sections.		Average area of cross sections.		Average mean depth at bank-full stage.	
		Bank-full stage.	When sounded.							
			1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*
	889									
1	890.5	30	23.2	10.6	3,427	3,375	189,152	188,884	55.3	55.7
2	891.8	30	22	10.5	2,637	2,646	226,004	214,240	86.8	82.4
3	892.8	30	21.8	10.4	2,504	2,554	185,737	195,197	74.9	76.5
4	895	30	19.7	11.3	2,349	2,387	200,287	201,020	85.6	84.4
5	898.1	30	17.5	11.7	2,201	2,240	166,583	164,743	75.7	73.6
6	900.1	30	18.5	11.9	2,323	2,339	177,600	172,714	76.9	73.1
7	901	29.9	16	12.3	2,314	2,236	187,194	184,846	81.8	83
8	903	28.8	15.8	12.3	2,359	2,300	180,505	183,348	77.2	80.2
9	906.1	29.1	15.5	12.6	2,544	2,566	174,680	176,038	68.7	68.6
10	909	30	15.4	12.5	2,604	2,676	199,036	206,024	77.1	77.6
11	910.5	29	15.3	12.5	3,095	3,039	188,112	181,824	60.8	59.8
12	912.1	30	15.2	12.2	2,956	2,912	185,620	192,200	63.1	65.8
13	912.8	29.9	15.1	11.7	2,500	2,541	200,000	205,869	80.3	81.6
14	914.3	29.7	14.8	11.5	2,296	2,428	183,276	191,284	80.3	79
15	917.7	28.8	14.2	11.3	2,530	2,544	177,608	180,161	71.5	71.1
16	919.5	27.1	13.7	10.8	2,565	2,577	170,437	178,093	66.6	67.2
17	920.7	26.7	13.4	10.7	2,799	2,822	181,111	184,680	65.6	66.3
18	922.2	25.4	13.1	10.8	2,904	2,890	266,905	258,047	93.3	89.5
19	923.3	26.7	12.9	10.7	2,471	2,562	183,871	183,338	74	71.6
20	926	27.5	12.8	10.5	2,417	2,460	177,629	183,915	73.9	75.1
21	927.1	26.1	12.6	10.2	2,189	2,230	166,629	168,651	76.4	75.8
22	928.6	26.6	12.5	10.4	1,996	2,039	165,508	171,948	83.2	84.7
23	930.1	26.8	12.5	10.4	2,828	2,816	189,096	192,340	66.9	68.5
24	931.1	25.9	12.4	11.6	3,501	3,528	200,360	208,560	57.7	59.8
25	932.7	25	12.2	11.8	3,571	3,747	155,320	158,808	43.9	42.6
26	935.8	25	12	11.9	2,577	2,561	190,612	190,118	74.7	74.6
27	937.4	25	11.8	12.8	2,342	2,396	164,508	168,118	68.3	70.2
28	938.6	25	11.8	12.8	2,426	2,500	163,394	176,531	66.7	70.7
29	939.7	23.9	11.7	13.2	3,164	3,193	167,451	174,354	53.2	54.7
30	942.4	25	11.7	14.3	2,737	2,618	249,695	251,162	90.3	95.7
31	944.5	23.7	11	15.8	2,393	2,410	168,391	167,018	70.6	69.4
32	946.2	24.1	10.6	16	2,178	2,171	167,683	169,250	76.8	78.4
33	948.2	24.3	10.5	16.7	2,488	2,514	178,453	181,487	72.1	72.4
34	952.4	23.5	9.8	17.1	2,630	2,675	171,477	174,046	66.2	66
35	953.7	22.8	9.1	17.4	1,987	2,026	173,529	178,369	87.5	88.3
36	957.3	22.6	9.1	17.6	2,582	2,583	177,599	178,187	71	70.8
37	958.7	23.5	9	17.8	2,804	2,850	178,904	186,396	63	65.4
38	960.3	23	9	18	2,591	2,618	219,927	227,650	86.6	88.3
39	961.7	23.8	8.9	17.9	2,571	2,520	183,693	181,173	71.5	71.6

NOTE.—The bank-full stage used in these tables corresponds to the elevation of the top of bank at each section.

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TABLE NO. 3 B.—*Averages of cross-section elements, Scot Bluffs, Louisiana, to Donaldsonville, La.*

LOW WATER.

	Average width.		Average area.		Average mean depth.		Average maximum depth.	
	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.	1895–96.	1897–98.
	Feet.	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Bends	2,389	2,387	113,396	124,821	49.9	54.9	96.8	108.8
Crossings	2,653	2,668	103,025	105,462	39.6	40.3	64.9	69.3

MEDIUM STAGE.

Bends	2,759	2,749	156,596	166,723	58.4	63.4	.....	.....
Crossings	2,935	2,957	151,607	154,234	52.5	53	.....	.....

BANK-FULL STAGE.

Bends	2,981	2,975	186,692	196,769	64.3	68.3	.....	.....
Crossings	3,084	3,099	183,188	185,592	60.1	60.7	.....	.....

BENDS AND CROSSINGS COMBINED.

Low water	2,498	2,503	109,099	116,303	45.6	48.9	83.5	92.1
Medium stage	2,844	2,835	154,529	161,549	55.9	59.1	.....	.....
Bank-full stage	3,024	3,027	185,240	192,138	62.6	65.1	.....	.....

NOTE.—Number of sections in bends = 229; number of sections in crossings = 162; total = 391.

TABLE NO. 3 C.—*Comparison of cross-section elements, Scot Bluffs, Louisiana, to Donaldsonville, La.—Summary of changes in mean elements, surveys of 1882–83 and 1895–96.*

AT LOW WATER.

	Bends (97 sections, 33.3 miles).	Crossings (73 sections, 24.8 miles).	Entire reach (170 sections, 58.1 miles).
Width	Increased 46 feet, or 2 per cent.	Increased 123 feet, or 4.8 per cent.	Increased 79 feet, or 3.2 per cent.
Area	Decreased 9,181 square feet, or 7.5 per cent.	Decreased 2,439 square feet, or 2.3 per cent.	Decreased 6,303 square feet, or 5.5 per cent.
Mean depth	Decreased 3.9 feet	Decreased 3 feet	Decreased 3.5 feet.
Maximum depth	Decreased 7.3 feet	Decreased 5.8 feet	Decreased 6.6 feet.

AT MEDIUM STAGE.

Width	Increased 144 feet, or 5.5 per cent.	Increased 253 feet, or 9 per cent.	Increased 190 feet, or 7 per cent.
Area	Decreased 4,631 square feet, or 2.8 per cent.	Increased 292 square feet, or $\frac{1}{10}$ of 1 per cent.	Decreased 3,390 square feet, or 2.1 per cent.
Mean depth	Decreased 6.9 feet	Decreased 7.5 feet	Decreased 7.1 feet.

AT BANK-FULL STAGE.

Width	Decreased 54 feet, or 1.8 per cent.	Increased 96 feet, or 3.2 per cent.	Increased 12 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Decreased 2,351 square feet, or 1.2 per cent.	Increased 796 square feet, or $\frac{1}{10}$ of 1 per cent.	Decreased 1,352 square feet, or $\frac{1}{10}$ of 1 per cent.
Mean depth	Increased 0.5 foot	Decreased 1.4 feet	Decreased 0.3 foot.

NOTE.—In this comparison 1882–83 is taken as standard.

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TABLE NO. 3 D.—*Comparison of cross-section elements, Scot Bluffs, Louisiana, to Donaldsonville, La.—Summary of changes in mean elements, surveys of 1895–96 and 1897–98.*

AT LOW WATER.

	Bends (229 sections, 33.3 miles).	Crossings (162 sections, 24.8 miles).	Entire reach (391 sections, 58.1 miles).
Width	Decreased 2 feet, or $\frac{1}{10}$ of 1 per cent.	Increased 15 feet, or $\frac{1}{10}$ of 1 per cent.	Increased 5 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Increased 10,425 square feet, or 9.2 per cent.	Increased 2,437 square feet, or 2.4 per cent.	Increased 7,204 square feet, or 6.6 per cent.
Mean depth	Increased 5 feet, or 10 per cent.	Increased 0.7 foot, or 1.8 per cent.	Increased 3.3 feet, or 7.2 per cent.
Maximum depth	Increased 12 feet, or 12.4 per cent.	Increased 4.4 feet, or 6.8 per cent.	Increased 8.6 feet, or 10.3 per cent.

AT MEDIUM STAGE.

Width	Decreased 31 feet, or 1.1 per cent.	Increased 22 feet, or $\frac{1}{10}$ of 1 per cent.	Decreased 9 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Increased 10,127 square feet, or 6.5 per cent.	Increased 2,627 square feet, or 1.7 per cent.	Increased 7,020 square feet, or 4.5 per cent.
Mean depth	Increased 5 feet, or 8.6 per cent.	Increased 0.5 foot, or 1 per cent.	Increased 3.2 feet, or 5.7 per cent.

AT FULL-BANK STAGE.

Width	Decreased 6 feet, or $\frac{1}{10}$ of 1 per cent.	Increased 15 feet, or $\frac{1}{10}$ of 1 per cent.	Increased 3 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Increased 10,077 square feet, or 5.3 per cent.	Increased 2,404 square feet, or 1.3 per cent.	Increased 6,898 square feet, or 3.7 per cent.
Mean depth	Increased 4 feet, or 6.2 per cent.	Increased 0.6 foot, or 1 per cent.	Increased 2.5 feet, or 4 per cent.

NOTE.—In this comparison 1895–96 is taken as standard.

TABLE NO. 3 E.—*Comparison of cross-section elements, Scot Bluffs, Louisiana, to Donaldsonville, La.—Summary of changes in mean elements, surveys of 1882–83 and 1897–98.*

AT LOW WATER.

	Bends (97 sections, 33.3 miles).	Crossings (73 sections, 24.8 miles).	Entire reach (170 sections, 58.1 miles).
Width	Increased 69 feet, or 3 per cent.	Increased 128 feet, or 5 per cent.	Increased 97 feet, or 4 per cent.
Area	Increased 1,738 square feet, or 1.4 per cent.	No change	Increased 806 square feet, or $\frac{1}{10}$ of 1 per cent.
Mean depth	Decreased 0.2 foot, or $\frac{1}{10}$ of 1 per cent.	Decreased 2.3 feet, or 5.5 per cent.	Decreased 1.2 feet, or 2.8 per cent.
Maximum depth	Increased 2.8 feet, or 2.7 per cent.	Decreased 1.3 feet, or 1.8 per cent.	Increased 1.2 feet, or 1.3 per cent.

AT MEDIUM STAGE.

Width	Increased 128 feet, or 4.9 per cent.	Increased 285 feet, or 10.6 per cent.	Increased 153 feet, or 5.7 per cent.
Area	Increased 782 square feet, or $\frac{1}{10}$ of 1 per cent.	Increased 2,394 square feet, or 1.6 per cent.	Increased 1,710 square feet, or 1.1 per cent.
Mean depth	Decreased 3.7 feet, or 5.6 per cent.	Decreased 2.6 feet, or 4.7 per cent.	Decreased 3.3 feet, or 5.3 per cent.

AT BANK-FULL STAGE.

Width	Decreased 66 feet, or 2.3 per cent.	Increased 89 feet, or 3 per cent.	Increased 2 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Increased 5,223 square feet, or 2.7 per cent.	Increased 3,775 square feet, or 2.1 per cent.	Increased 4,157 square feet, or 2.3 per cent.
Mean depth	Increased 4.4 feet, or 6.7 per cent.	No change	Increased 2.4 feet, or 3.7 per cent.

NOTE.—In this comparison 1882–83 is taken as standard.

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TABLE NO. 3 F.—*Comparison of cross-section elements, Donaldsonville, La., to Carrollton, La.—Summary of changes in mean elements, surveys of 1893–94 and 1897–98.*

AT LOW WATER.

	Bends (279 sections, 40.6 miles).	Crossings (210 sections, 32.1 miles).	Entire reach (489 sections, 72.7 miles).
Width	Decreased 22 feet, or 1 per cent.	Decreased 27 feet, or 1.2 per cent.	Decreased 24 feet, or 1 per cent.
Area	Increased 2,686 square feet, or 1.8 per cent.	Increased 2,035 square feet, or 1.6 per cent.	Increased 2,386 square feet, or 1.7 per cent.
Mean depth	Increased 2 feet, or 3 per cent.	Increased 1.6 feet or 2.8 per cent.	Increased 1.8 feet, or 2.9 per cent.
Maximum depth	Increased 2.2 feet, or 2 per cent.	Increased 2.2 feet, or 2.5 per cent.	Increased 2.1 feet, or 2.1 per cent.

AT BANK-FULL STAGE.

Width	Increased 13 feet, or $\frac{1}{10}$ of 1 per cent.	Increased 23 feet, or $\frac{2}{10}$ of 1 per cent.	Increased 18 feet, or $\frac{1}{10}$ of 1 per cent.
Area	Increased 2,375 square feet, or 1.2 per cent.	Increased 1,611 square feet, or $\frac{1}{10}$ of 1 per cent.	Increased 2,046 square feet, or 1.1 per cent.
Mean depth	Increased 0.3 foot, or $\frac{1}{10}$ of 1 per cent.	No change	No change.

NOTE.—In this comparison 1893–94 is taken as standard.

TABLE NO. 3 G.—*Averages of cross-section elements, Donaldsonville, La., to Carrollton, La.*

LOW WATER.

	Average width.		Average area.		Average mean depth.		Average maximum depth.	
	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.	1893–94.	1897–98.
Bends	2,281	2,259	147,287	149,973	65.3	67.3	112.6	114.8
Crossings	2,321	2,294	128,991	131,026	56.6	58.2	86.8	89

BANK-FULL STAGE.

Bends	2,553	2,566	192,693	195,068	76.4	76.7	.....	.....
Crossings	2,610	2,633	176,911	178,522	69.3	69.3	.....	.....

BENDS AND CROSSINGS COMBINED.

Low water	2,298	2,274	139,430	141,816	61.6	63.4	101.6	103.7
Bank-full stage	2,577	2,595	185,916	187,962	73.3	73.5	.....	.....

NOTE.—Number of sections in bends=279; number of sections in crossings=210; total=489.

APPENDIX 1 D.

REPORT OF MR. W. S. WILLIAMS, SURVEYOR, ON PRECISE-LEVEL WORK FROM ST. PAUL, MINN., TO AITKIN, MINN.

ST. LOUIS, MO., *March 17, 1899.*

CAPTAIN: I have the honor to submit the following report on precise-level work from St. Paul, Minn., to Aitkin, Minn.

A single precise-level party was organized for this work at Minneapolis, Minn., on June 6, 1898. It consisted of the following members: W. S. Williams, observer; E. E. Whitehead, recorder; two rodmen and two umbrella men.

The party camped and subsisted with the secondary triangulation party in charge of Asst. Engineer A. T. Morrow, and assisted that party in measuring base lines. The party was transported to and from work by a two-horse wagon.

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The instrumental constants having been determined only a short time before at Head of Passes, April 20, 1898, they were not determined at the beginning of this work, but were determined at the close of the season at Aitkin, Minn.

Field work began on June 6, 1898, and closed November 12, 1898, the party having been in the field one hundred and sixty days, or, excluding holidays and Sundays, one hundred and thirty-six working days. During this time 197.33 miles of main line and 24.86 miles of side line were run, making a total of 222.19 miles, or an average of 1.63 miles per working day; this being run in both directions, makes the daily average 3.26 miles of single line.

The instruments used were Kern precise level No. 4, Fauth bubble No. 214, and Kern precise leveling rods Nos. XVIII and XIX. The rod supports for turning points were footplates and pins; the footplates were used on most of the line, the soil being mostly of a sandy nature, pins being used only in woodland.

Route.—The line commenced at P. B. M. 65 on Eagle street in St. Paal, Minn., and followed the Chicago, Milwaukee and St. Paul Short Line Railway to University avenue in East Minneapolis, Minn.; through East Minneapolis on streets, then followed the wagon roads nearest the river on the left bank to Brainerd, Minn., except a few miles where the railroad track was used or the line made cut offs across fields and woodland; at North Brainerd the line crossed the river and followed the wagon road on right bank to a point opposite the mouth of Rabbit River; then through the timber about 4 miles and crossed back to left bank one-fourth of a mile above the mouth of Rabbit River; from this point to Deans Brook the line followed the left bank of the river through the woods, cutting off a few sharp bends; from Deans Brook to Aitkin, Minn., the line followed the wagon road and ended at ⓐ Lower Base, 1 mile above Aitkin.

The different kinds of ground leveled over in the main line are about as follows: Wagon roads, 133 miles; railroads, 17 miles; paved streets, 3 miles; cultivated fields, 14 miles; woodland and along river bank, 30 miles.

Connections with former levels.—A line of ordinary levels was run over this part of the river in 1874, under the direction of United States engineer office at St. Paul, Minn. (see Corps of Engineers Report, 1881, p. 1813); but the bench marks established were mostly of such a temporary character, being nearly all nails in trees, and their descriptions so indefinite, that but few connections were made with this line.

These connections are shown in the following tabulation:

Table showing comparison of precise levels with ordinary levels run in 1874.

Point of comparison.	Distance from St. Paul as per line run.	Precise-level elevation above mean Gulf level (preliminary value).	Elevation above sea level, by report 1881, ordinary levels.	Discrepancy.
	Miles.	*Feet.*	*Feet.*	*Feet.*
Zero of signal service gauge at St. Paul, Minn.	.....	683.334	682.536	—0.798
T. B. M. 110, opposite mouth of Sauk River	88	1,003.532	1,004.620	+1.088
P. B. M. Sanitarium at Brainerd, Minn.	154	1,207.604	1,209.810	+2.206
Top of tie on Northern Pacific R. R. at east end of depot at Aitkin, Minn	197	1,208.920	1,211.353	2.433

Connection with bench mark on Pillsbury Hall at Minnesota State University in East Minneapolis, established by Prof. William Hoag under the direction of United States Coast and Geodetic Survey, gives the following comparison:

	Feet.
Elevation above mean Gulf level (preliminary value) by M. R. C. levels	847.065
Elevation above mean Gulf level (preliminary value) by Professor Hoag's levels	846.965
Discrepancy	.100

Bench marks.—The tile and pipe bench marks used were of the standard form as modified in 1898. For description see note under the head of "Descriptions and elevations of precise-level bench marks." Other bench marks, such as copper bolts leaded into stone foundations and bridge piers, squares cut in stone, and nails in roots of trees were established. All of the stone line bench marks on the left bank (except $3\frac{1}{2}^{R}$) between $2\frac{U}{2}^{A}$ in Minneapolis and $3\frac{3}{4}^{S}$ in Aitkin were connected with. The descriptions of all the P. B. M.'s and such T. B. M.'s as are of a permanent nature and may be used in the near future are appended.

Methods of field work.—The methods pursued are those described in the latest instructions for precise leveling, issued by the Mississippi River Commission.

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Instrumental constants.

[Kern telescope No. 4.]

Date of observation.	Dates to be used between—	Inequality of rings = correction P in millimeters per meter.	Wire interval in millimeters per meter.
Apr. 20, 1898	June 6–Aug. 1, 1898	—0.045	4.29
Oct. 29, 1898	Aug. 1–Nov. 12, 1898	— .042	4.25

Value of one division of level tube, Fauth No. 214.

Date of observation.	Dates to be used between—	Value in seconds of arc.	Value in millimeters per meter.	Distance in meters at which 1 division subtends 1 millimeter.
Apr. 20, 1898	June 6–Aug. 1, 1898	2.64	0.01279	78.2
Oct. 29, 1898	Aug. 1–Nov. 12, 1898	2.34	.01133	88.3

Value of the correction "A" for rods XVIII and XIX is 56 millimeters, as determined April 20, 1898. In the office reduction the standard length of 1 meter on rods XVIII and XIX has been taken to be 1 00012 meters, this value being a mean between the values determined for these rods by O. W. Ferguson, in 1891 and 1893. (See Chief of Engineers Report, 1893, p. 3960.)

Results.

	Km.	Miles.
Length of main line completed	317.572	= 197.33
Length of side line completed	40.013	= 24.86
Total	357.585	= 222.19

The main line is composed of 268 stretches, the average length of stretch being 1,185 meters.

The direct and reverse lines diverge irregularly from the mean for 33 miles, where they are ∓ 10.4 millimeters, being 20.8 millimeters apart; then they converge and come together 48 miles from the initial point; then they run very near together, crossing and recrossing, for the next 26 miles; then they begin to diverge and reach the maximum divergence of ∓ 15.76 millimeters, being 31.52 millimeters apart at 162 miles from the initial point; then they vary irregularly until the end of the line at Aitkin, where they are ∓ 12.95 millimeters or 25.90 millimeters apart. This shows that there are no constant errors of any considerable magnitude in the work.

Of the 268 stretches in the main line, only 10 failed to close inside the prescribed limit on first trial. Of these, 5 were closed inside the limit by running a third line, and 5 were closed inside the limit by running a fourth line, no more than four lines being run in any stretch. All side lines closed inside of the prescribed limit on first trial, except 1, where a third line was run.

All results obtained have been retained in the computations, there being no discrepancies large enough to justify their being discarded on account of accidental errors. The largest closure between any pair of lines is 11.1 millimeters on a stretch 1,304 meters long. The largest variations from the mean result of any stretch are one of 7.32 millimeters and one of 6 millimeters.

The probable error in the final elevation of ⏃ lower base at Aitkin is computed through the probable error of each stretch in the 317.572 kilometers is ∓ 9.66 millimeters.

The probable error per kilometer in the main line is ∓ 0.54 millimeters.

To connect the work at St. Paul 6 bench marks were connected with, and by giving each of these equal weight an adjusted elevation of 223.8444 meters is obtained for P. B. M. 65, and the reductions in the tabulation have been made from this elevation, which differs only 0.5 millimeters from the former elevation for P. B. M. 65.

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TABULATION OF PRECISE LEVEL RESULTS, FROM ST. PAUL, MINN., TO AITKIN, MINN.

In the following tabulation, column 1 gives the bench mark under consideration. P. B. M. denotes a permanent precise bench mark, and T. B. M. denotes a temporary precise bench mark, but in some cases it is quite permanent.

Column 2 gives the bench mark from which the bench mark in column 1 was determined.

Column 3 gives the distance run between the bench marks in the two preceding columns.

Column 4 gives the total distance of the bench mark under consideration from the initial point, i. e., P. B. M. 65.

Column 5 gives the direction each line was run.

Column 6 gives the difference in elevation between the bench marks in columns 1 and 2 determined by each run, with its proper sign and the mean of all the runs.

Column 7 gives the residuals found by subtracting each result from the mean result.

Columns 8 and 9 give the algebraic sum of the residuals, and show at every bench mark the amount that the two independent (direct and reverse) lines diverge from the mean.

Column 10 gives the probable error of each stretch, computed by the formula $r = 0.6745\sqrt{\frac{\Sigma \cdot v^2}{m(m-1)}}$

Column 11 gives the probable error for each bench mark when referred to the first bench mark, or starting point; computed by the formula $R = \sqrt{\Sigma r^2}$.

Column 12 gives the rod correction that has been applied to the elevation of each bench mark to correct the meter on rods used to the standard meter.

Columns 13 and 14 give the elevations of the bench marks in column 1 in meters and feet. Value of 1 meter = 3.2808693 feet.

Immediately following this report will be found a description of the methods which have been followed in doing precise level work.

Respectfully submitted.

W. S. WILLIAMS, *Surveyor.*

Capt. MASON M. PATRICK,
Corps of Engineers, U. S. A.

TABLE NO. 4.

DESCRIPTIONS AND ELEVATIONS OF PRECISE LEVEL BENCH MARKS, ST. PAUL, MINN., TO AITKIN, MINN.

[Season of 1898. W. S. Williams, leveler.]

Elevations are expressed in both meters and feet above the Cairo datum plane. One meter is taken as 3.2808693 feet.

Preliminary value of mean Gulf level at Biloxi, Miss., is 21.26 feet above the Cairo datum plane.

The letters P. B. M. denote a precise level bench mark which is set with special care so as to be practically permanent; those described as a tile and pipe consist of a vitrified tile 18 by 18 by 4 inches, in the center of which is set vertically with lead a three-eighths-inch copper bolt, the upper end being a little above the upper surface of the tile. Surrounding the bolt on the surface of the tile is the inscription "Mississippi River Commission, 1898, U. S., P. B. M." This tile is buried in the ground from 3 to 3½ feet beneath the surface. On top of the tile is placed a 4-inch wrought-iron gas pipe 4 feet long concentric with the copper bolt; the lower end of the pipe is split into quarters and spread out to prevent the pipe from heaving by frost or being pulled up. A cast brass cap fits over the top of the pipe, and is riveted thereto. The cap has the following inscription in sunken letters "Mississippi River Commission, $250 fine for disturbing this mark. 1898. P. B. M., U. S. Latitude. Longitude. Elevation above sea." The elevation of the top of the cap is determined; the structure has thus two bench marks. The letters T. B. M. denote a temporary bench mark whose elevation is as well determined as that of a P. B. M.; those described are considered practically permanent for a number of years.

All witness trees are blazed with a △ facing the bench mark.

P. B. M. 65 is in St. Paul, on the southeast corner of Washington and Eagle streets, 9.2 feet from the south side of Washington, 1 foot above the old city storehouse which stands on the east side of Eagle, in center of a regulation tile 18 inches square and 4 inches thick set 2½ feet below the surface of the ground, being the top of a three-eighths-inch copper bolt leaded vertically. Established in 1891.

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Elevation 223.8444 meters, 734.404 feet.

T. B. M. 1 (Ferguson, 1891) is in St. Paul on the southeast corner of Washington and Eagle streets, on curbing, directly over the center of inlet grating, being the highest point in square cut in the granite.

Elevation, 224.5255 meters, 736.639 feet.

T. B. M. 67 is in St. Paul, on left bank of the Mississippi River, on the shore pier of the Wabasha Street Bridge; on the northwest corner of the upper pier, 6 inches from bridge seat stone; being the top of copper bolt leaded vertically, marked U. S. ⊙ P. B. M. Established in 1891.

Elevation, 222.0675 meters, 728.574 feet.

P. B. M. 68 is in St. Paul, on the left bank of the Mississippi River on lower wing wall of Chicago, St. Paul and Kansas City Railway (now Chicago Great Western Railway) Bridge, 4.76 feet above the lower end of bridge seat course and 2.75 feet back from its front edge, being top of copper bolt leaded vertically, marked U. S. ⊙ P. B. M. Established in 1891.

Elevation, 220.4214 meters, 723.174 feet.

P. B. M. 70 is in St. Paul, about 100 feet west of Jackson street, on north side of railroad tracks, opposite the Diamond Jo freight depot, at the east end of retaining wall and 4 inches back of its face, being the top of copper bolt leaded in regulation tile. Established in 1891.

Elevation, 220.8679 meters, 724.639 feet.

Old U. S. B. M. "A" is in St. Paul, on the left bank of the Mississippi River, on the lower bench of retaining wall of embankment of the Chicago, St. Paul and Kansas City Railway Bridge (now Chicago Great Western Railway), being the highest point in ring cut in top of stone, marked ⊙.

Elevation, 221.6378 meters, 727.165 feet.

T. B. M. 23 is in St. Paul, Minn., being a square, □, cut in top stone on north end of east abutment of Chicago, Milwaukee and St. Paul Railway Bridge over Pleasant avenue, a quarter of a mile east of Ridgewood Station; square is about 4 inches from northwest corner of stone.

Elevation, 254.6941 meters, 835.618 feet.

T. B. M. 22 is in St. Paul, Minn., on north end of east abutment of Chicago, Milwaukee and St. Paul Railway Bridge over Victoria street, 50 meters east of Ridgewood Station on Chicago, Milwaukee and St. Paul Railway Short Line, between St. Paul and Minneapolis; being the highest point in square cut in top of stone, 8 inches from the northwest corner of stone, marked U. □ S.

Elevation, 258.5532 meters, 848.279 feet.

P. B. M. Macalester is a tile and pipe on south side of the Chicago, Milwaukee and St. Paul Railway Short Line, between St. Paul and Minneapolis, 250 meters east of Snelling avenue, 16 rail lengths east of center of Macalester Station, 11 meters south of center of south track, 3½ meters east of 10-inch cottonwood, on which is located T. B. M. 19.

Elevation bolt in tile, 290.4784 meters, 953.022 feet.

Elevation cap on pipe, 291.6879 meters, 956.990 feet.

T. B. M. 18 is in St. Paul, Minn., on west abutment of Chicago, Milwaukee and St. Paul Railway Bridge over Prior avenue, about 30 meters east of center of Marian Park Station, about 10 inches from the south and east edges of stone at southeast corner of south end of abutment, marked U. □ S.

Elevation, 283.1596 meters, 929.010 feet.

T. B. M. 16 is on the Pelham Street Bridge over the Chicago, Milwaukee and St. Paul Railway tracks, about 70 meters east of Desnoyer Park Station in west end of St. Paul, Minn.; being a square cut on the southwest corner of stone pedestal under west column on north side of tracks, marked U. □ S.

Elevation, 271.1240 meters, 889.522 feet.

T. B. M. 14 is a nail in root of 14-inch cottonwood tree, about 12 meters west of Chicago, Milwaukee and St. Paul Railway track, 80 meters south of intersection of Dartmouth street and railroad track, near Prospect Park in East Minneapolis, Minn.

Elevation, 259.3150 meters, 850.779 feet.

T. B. M. 13 is a square cut in northeast corner of top of large square granite stone on north side of entrance to State University grounds in Southeast Minneapolis, Minn., at northwest corner of University avenue and Fifteenth avenue SE.

Elevation 262.3066 meters, 860.594 feet.

P. B. M. University Campus is a copper bolt in center of stone post in Minnesota State University campus in southeast Minneapolis, on north side of Pleasant street, 1 meter north of granitoid walk, 34 meters west of intersection of Pleasant street and street running along in front of University buildings, 15 meters south of Mechanic Arts building; stone post is about 6 inches above ground.

Elevation, 263.0087 meters, 862.897 feet.

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P. B. M. Pillsbury Hall is a horizontal line in center of bronze plate set into wall of tower on north side of the south entrance to Pillsbury Hall at Minnesota State University in southeast Minneapolis, Minn.; it is 18 inches above ground and 2 meters from junction of tower and wall of main building on north side of tower. Bronze plate marked with the letters "U. S. C. and G. S."

Elevation, 264.6631 meters, 868.325 feet.

T. B. M. 12 is a square cut on top of stone cover of catch basin at southwest corner of University avenue and Tenth avenue, southeast Minneapolis, Minn., 3 inches back of curb line on west side of University avenue, marked U. □ S.

Elevation, 258.6407 meters, 848.566 feet.

P. B. M. $\frac{2}{3}$ is a tile and pipe in southeast Minneapolis, Minn., on left bank of Mississippi River, about 150 meters below end of Great Northern Railway bridge over the Mississippi River below St. Anthony Falls, one-half meter west of west right-of-way fence of Great Northern Railway, and 5 meters north of corner of fence.

Elevation bolt in tile, 248.2471 meters, 814.466 feet.

Elevation cap on pipe, 249.4601 meters, 818.446 feet.

P. B. M. Great Northern is a square cut in top of west end of south abutment of bridge on University avenue over Great Northern Railway tracks on Second avenue, northeast Minneapolis, Minn., in center of abutment, 6 inches from west end; marked U. S. □ P. B. M.

Elevation, 264.6036 meters, 868.130 feet.

P. B. M. Brewery office is a square cut in the north end of lowest step of main entrance to the office of the Minneapolis Brewing Company, on the east side of Marshall street, between Twelfth and Thirteenth avenues, northeast Minneapolis, Minn.; step is 1 inch above sidewalk, marked U. S. □ P. B. M.

Elevation, 254.9855 meters, 836.574 feet.

T. B. M. 11 is a square cut on top of north end of east abutment of Northern Pacific Railway bridge over the Mississippi River at end of Seventeenth avenue, northeast Minneapolis, Minn.; square is 8 inches from north edge and 5 inches from west edge of top stone of abutment, 2.3 meters above bridge seat.

Elevation, 258.4529 meters, 847.950 feet.

P. B. M. Gluck is a copper bolt leaded vertically into top of water table at southeast corner of main building of Gluck's Brewery, on west side of Marshall street, between Twentieth and Twenty-first avenues, northeast Minneapolis, Minn., 17 meters from iron gate on Marshall street; bolt is 4.3 feet above ground, marked U. S. ⊙ P. B. M.

Elevation, 259.5656 meters, 851.601 feet.

T. B. M. 1 is a wire nail in west root of 10-inch oak on west side of Marshall street, Minneapolis, Minn., second tree from lower end of row along vacant lots opposite Republic Elevator, about 100 meters above P. B. M. $\frac{2}{5}$.

Elevation, 259.8054 meters, 852.387 feet.

P. B. M. $\frac{2}{5}$ is a tile and pipe on left bank of Mississippi River one-fourth meter north of a fence on north line of Twenty-seventh avenue, northeast Minneapolis, Minn., 5 meters east of fence corner and 72 meters west of west line of Marshall street.

Elevation bolt in tile, 259.2130 meters, 850.444 feet.

Elevation cap on pipe, 260.4265 meters, 854.425 feet.

T. B. M. 3 is a square cut in southwest corner of stone doorstep at main entrance to Louis Opshal's hotel and saloon, on northeast corner of Marshall street and Forty-second avenue, northeast Minneapolis, Minn., property of Minneapolis Brewing Company. Marked U. □ S.

Elevation, 260.1313 meters, 853.457 feet.

T. B. M. 4 is a wire nail in root on southwest side of 15-inch cottonwood in pasture on east side of road, opposite residence of Mrs. Fridley, 980 meters above T. B. M. 3.

Elevation, 259.7793 meters, 852.302 feet.

T. B. M. 5 is a wire nail in west root of 8-inch elm tree, on fence line on river side of road, 125 meters above angle in road and 325 meters above P. B. M. $\frac{2}{7}$.

Elevation, 259.8475 meters, 852.526 feet.

P. B. M. $\frac{2}{7}$ is a tile and pipe about three-fourths of a mile above upper limits of Minneapolis, Minn., and one-fourth of a mile above center line of section 27, on left bank of Mississippi River, at junction of fences, one-half meter west of fence, on west side of wagon road and one-half meter south of fence running west from road, about 75 meters back from river bank, 500 meters above angle in road, 200 meters below another angle in road.

Elevation bolt in tile, 259.6595 meters, 851.909 feet.

Elevation cap on pipe, 260.8666 meters, 855.869 feet.

T. B. M. 6 is a wire nail in root of 15-inch elm at angle in wagon road 1 mile above P. B. M. $\frac{2}{7}$, 10 meters above residence of C. C. Hays, on river side of road.

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Elevation, 263.4202 meters, 864.247 feet.

T. B. M. 7 is a wire nail in root of 12-inch elm in front of deserted house on river side of public road 1¼ miles above P. B. M. $2\frac{11}{12}$.

Elevation, 261.6132 meters, 858.319 feet.

T. B. M. 8 is a wire nail in north root of 20-inch cottonwood in front of Fridley post-office and grocery store at Fridley mill, on left bank of Mississippi River, about 5 miles above Minneapolis, Minn.; the tree is the upper one of three trees, and the nail is 18 inches from the trunk of the tree.

Elevation, 260.4708 meters, 854.571 feet.

P. B. M. $2\frac{8}{12}$ is a tile and pipe about 3½ miles above the city limits of Minneapolis, Minn., about one-half mile above Fridley post-office, 100 meters back from left bank of river, on property of McMullen, one-half mile above Rice Creek, one-half meter south of an east and west fence along south side of cultivated strip and at corner of timber. Blazed trees: 10-inch oak, 349°—2.6 meters; 6-inch oak, 267°—4.6 meters.

Elevation bolt in tile, 264.4220 meters, 867.534 feet.

Elevation cap on pipe, 265.6340 meters, 871.510 feet.

T. B. M. 9 is a wire nail in root of 14-inch oak 12 meters east of public road, three-fourths of a mile above Fridley mill, about 90 meters above corner of cultivated field on west side of road, and 40 meters below culvert under road.

Elevation, 267.1052 meters, 876.337 feet.

T. B. M. 10 is a wire nail in south root of a 10-inch post oak 25 meters west of wagon road, 1¼ miles above Fridley mill, 10 meters west of large post oak, 235 meters north of junction of roads, and 75 meters south of corner of cultivated field. Tree marked with a triangular blaze.

Elevation, 268.2923 meters, 880.232 feet.

T. B. M. 26 is a nail in east root of a double oak tree on west side of public road 3½ miles above Fridley mill, trees 10 inches in diameter, on property of John Coleman and about 100 meters above his residence, on river side of road 5 meters from fence. Tree marked with a triangular blaze.

Elevation, 274.6093 meters, 900.957 feet.

T. B. M. 27 is on brick schoolhouse on public road between Minneapolis and Anoka, Minn., on left bank of Mississippi River, 4½ miles above Fridley mill and 6½ miles below Anoka; being a square cut on north end of lower step at front entrance to schoolhouse, near ⓐ Dunn.

Elevation, 276.7386 meters, 907.943 feet.

P. B. M. ⓐ Dunn is a tile and pipe on property of John Dunn, SW. ¼, SE. ¼, Sec. 26, T. 31, R. 24, 250 meters west of river road on left bank of river, about 9 miles above upper limits of Minneapolis, Minn. Station in timber opposite first angle in road, 120 meters above Dunn's (brick) schoolhouse. Blazed trees: 12-inch oak, 298°—7.4 meters; 10-inch oak, 353°—3.4 meters; 12-inch oak, 67°—3.8 meters; 8-inch oak, 143°—3.4 meters.

Elevation bolt on tile, 273.5463 meters, 897.470 feet.

Elevation cap on pipe, 274.7609 meters, 901.454 feet.

T. B. M. 29 is on Northern Pacific Railway bridge over Coon Creek, about 5 miles below Anoka, Minn.; being a square cut in granite stone on top of west end of north abutment of bridge.

Elevation, 266,9278 meters, 875.755 feet.

T. B. M. 30 is at junction of Coon Creek post-office road with Minneapolis and Anoka road, about 4½ miles below Anoka; being a nail in root of tree in corner of yard at the residence of John Dunn.

Elevation, 269.1499 meters, 883.046 feet.

P. B. M. $2\frac{9}{12}$ is a tile and pipe on left bank of river, about 200 meters above Dunn Island, three-fourths of a mile above mouth of Coon Creek, at the edge of timber, 100 meters back from river bank, on slope near the foot of bench, 40 meters north of east and west wagon road, on property of John Dunn. Blazed trees: 20-inch oak, 79°—4.2 meters; 15-inch oak, 152°—7.0 meters; 15-inch oak, 199°—7.9 meters.

Elevation bolt in tile, 260.7780 meters, 855.578 feet.

Elevation cap on pipe, 261.9834 meters, 859.533 feet.

P. B. M. ⓐ Powell is a tile and pipe on south side of river road about 3½ miles below Anoka, Minn., on left bank of river, on section line between sections 16 and 21, T. 31, R. 24, on line between property of George Smith and Lewis Greenwald, 2 meters north of south road fence, directly south of residence of S. J. Powell, one-half mile below district school No. 2. Blazed trees: 10-inch scrub oak, 101°—12.5 meters; 24-inch scrub oak, 352° 25′—12.3 meters.

Elevation bolt in tile, 270.5714 meters, 887.709 feet.

Elevation cap on pipe, 271.7864 meters, 891.696 feet.

P. B. M. $2\frac{10}{12}$ is a tile and pipe on top of left bank of river about 2¾ miles below wagon bridge over Mississippi River at Anoka, Minn., 1 meter south of east and west fence on section line between sections 17 and 20, T. 31 N., R. 24 W., about 150 meters west of section corner $\frac{17}{20}$ $\frac{19}{29}$, on property of Charles L. Gibbs. Blazed tree: 8-inch oak, 301°—3.5 meters.

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Elevation bolt in tile, 267.1984 meters, 876.643 feet.

Elevation cap on pipe, 268.4066 meters, 880.607 feet.

T. B. M. 34 is a wire nail in east root of 15-inch post oak, on west side of public road about 1 mile below Anoka, Minn., about 30 meters above D. W. Benton's house.

Elevation, 272.9190 meters, 895.412 feet.

T. B. M. 36 is in Anoka, Minn., being the extreme top of fire hydrant on east side of Minneapolis road, 40 meters south of its intersection with Third avenue.

Elevation, 273.5321 meters, 897.423 feet.

P. B. M. Anoka is on wagon bridge over Mississippi River at Anoka, Minn., being the top of a copper bolt leaded vertically into the top of upper end of first pier from left-bank end of bridge, or pier between abutment and draw pier, 2 feet from extreme upper point of pier, marked $\frac{\text{U. S.}}{\text{P. B. M.}}$

Elevation, 265.0909 meters, 869.729 feet.

The gauge at Anoka is a staff gauge, fastened to the downstream end of pier between abutment on left bank and the draw pier of wagon bridge over the Mississippi River at Anoka, Minn.

Elevation of zero, 848.762 feet.

P. B. M. $2\frac{1}{2}^{1}$ is a tile and pipe in Anoka, Minn., on left bank of river, 600 meters above wagon bridge over Mississippi River, in Rice street, one-fourth of a meter north of fence on south line of street, and about 75 meters east of where Rice street ends on river bank. Blazed 10-inch oak, 270°—42 meters.

Elevation bolt in tile, 262.9091 meters, 862.570 feet.

Elevation cap on pipe, 264.1223 meters, 866.551 feet.

P. B. M. $2\frac{1}{2}^{2}$ is a tile and pipe 3 miles above Anoka, Minn., on public road 800 meters back from left bank of river, opposite foot of Clouquet Island, in corner of fence, 1 meter west of fence on west side of road, on property of A. J. Smith, and 14 meters south of a point opposite south end of Smith's house. Blazed 18-inch elm, 312°—6.8 meters.

Elevation bolt in tile, 267.4924 meters, 877.607 feet.

Elevation cap on pipe, 268.7004 meters, 881.571 feet.

T. B. M. 43 is a nail in root of lone elm tree on west side of public road, 1,860 meters above P. B. M. $2\frac{1}{2}^{2}$.

Elevation, 270.8954 meters, 888.772 feet.

P. B. M. $2\frac{1}{2}^{3}$ is a tile and pipe on right of way of the Great Northern Railway, about one-half mile below Itasca Station, about 500 meters below schoolhouse, 200 meters above foot of Goodwins Island, 150 meters above lower end of railway curve, 75 meters above a milepost marked S. 107—St. P. 33, one-half meter south of north right of way fence.

Elevation bolt in tile, 274.4635 meters, 900.479 feet.

Elevation cap on pipe, 275.6739 meters, 904.450 feet.

P. B. M. $2\frac{1}{2}^{4}$ is a tile and pipe, 3 miles below Elk River, Minn., 500 meters below lower end of Island No. 200, about 300 meters back from left bank of river, at edge of timber and cultivation, 1 meter toward river from wire fence on property of A. L. Stimson, Sec. 14, T. 32, R. 26 W., about 215 meters below Stimson's house. Blazed trees: 10-inch oak, 323°—9 meters; 4-inch oak, 61°—8.6 meters; 4-inch oak, 109°—6 meters.

Elevation bolt in tile, 276.2250 meters, 906.258 feet.

Elevation cap on pipe, 277.4314 meters, 910.216 feet.

P. B. M. $2\frac{1}{2}^{5}$ is a tile and pipe on left bank of river, 150 meters below ferry landing at lower end of town of Elk River, Minn., one-half meter toward river from west right of way fence of Great Northern and Northern Pacific railways, one-half meter west from junction of fences and nearly in line with center of north and south street.

Elevation bolt in tile, 277.9395 meters, 911.883 feet.

Elevation cap on pipe, 279.1446 meters, 915.837 feet.

T. B. M. 54 is in Elk River, Minn., being a nail in north root of 20-inch black oak on west side of railroad tracks, 10 rail lengths above center of Northern Pacific Railway depot, and 20 meters above upper corner of stock pen.

Elevation, 281.5896 meters, 923.859 feet.

P. B. M. Elk River is a square cut on top of iron cap on top of downstream cylinder of middle pier of wagon bridge over Elk River, just above milldam, 1 foot from down stream edge of cylinder. Marked U. ⊡ S.

Elevation, 272.4512 meters, 893.877 feet.

P. B. M. $2\frac{1}{2}^{6}$ is a tile and pipe opposite Otsego, Minn., in north and south public road, one-half meter west of wire fence along east line of road, about 150 meters back from left bank of river, 57 meters north of bend in road to ferry. Blazed trees: 5-inch oak, 85°—16.2 meters; 15-inch oak, 27° 50′—27.2 meters; 5-inch oak, 1°—15.4 meters.

Elevation bolt in tile, 279.8513 meters, 918.156 feet.

Elevation cap on pipe, 281.0574 meters, 922.113 feet.

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P. B. M. $2\frac{1}{2}^{7}$ is a tile and pipe on left bank of river, 6 miles below Monticello, Minn., 100 meters above head of Demicks Island, 75 meters from river bank, 1 meter east of wire fence along an old wagon road running nearly north. Blazed trees: 18-inch oak, 62°—10.2 meters; 18-inch oak, 269°—2 meters.

Elevation bolt in tile, 277.9223 meters, 911.827 feet.

Elevation cap on pipe, 279.1260 meters, 915.776 feet.

T. B. M. 65 is on public road, about 3 miles below Monticello, Minn., 20 meters below junction of Monticello road and road to Big Lake Station, 300 meters above P. B. M. $2\frac{4}{4}^{8}$; being a nail in south root of 10-inch post oak, on line of fence on south side of road, in front of residence of J. C. Johnson.

Elevation, 290.2713 meters, 952.342 feet.

P. B. M. $2\frac{1}{4}^{9}$ is a tile and pipe in public road, about 3 miles below Monticello, Minn., about 300 meters east of J. C. Johnson's house, 100 meters west of junction of fences, in Sec. 32, T. 33 N., R. 27 W., about 600 meters back from left bank of river, one-half meter south of fence on north line of road.

Elevation bolt in tile, 288.4968 meters, 946.520 feet.

Elevation cap on pipe, 289.6877 meters, 950.427 feet.

P. B. M. (△East Base (Monticello Base Line) is a tile and pipe in east and west public road on north side of river, about 1 mile below a point opposite lower limits of Monticello, Minn., 1 meter south of fence on north line of road. Adjoining property belongs to Mr. McAllester.

Elevation bolt in tile, 290.0988 meters, 951.776 feet.

Elevation cap on pipe, 291.3129 meters, 955.760 feet.

P. B. M. (△West Base (Monticello Base Line) is a tile and pipe in east and west public road on north side of river, opposite lower end of Monticello, Minn., about 200 meters below turn in the road at river bank, 1 meter south of fence on north side of road. Adjoining property belongs to Mr. Taft.

Elevation bolt in tile, 289.9834 meters, 951.398 feet.

Elevation cap on pipe, 291.1908 meters, 955.359 feet.

P. B. M. $2\frac{7}{7}^{9}$ is a tile and pipe in east and west public road, opposite upper end of picnic grounds at lower end of Monticello, Minn., one-half meter north of fence on south side of road, about 100 meters west of W. M. Taft's house, about 100 meters back from left bank of river, and 25 meters west of angle in fence.

Elevation bolt in tile, 290.7394 meters, 953.878 feet.

Elevation cap on pipe, 291.9462 meters, 957.837 feet.

T. B. M. 70 is on wagon bridge over Mississippi River at Monticello, Minn., being a square cut on top of stone cap of downstream cylinder of shore pier on left bank. Marked U. □ S.

Elevation, 284.5222 meters, 933.480 feet.

T. B. M. 71 is in public road, one-half mile above Monticello Bridge, on left bank of river, being a nail in root of 10-inch oak tree on north side of road, about 40 meters east of Mr. Cole's residence.

Elevation, 289.[illegible]298 meters, 951.222 feet.

P. B. M. $2\frac{8}{8}^{0}$ is a tile and pipe, about 2 miles above Monticello, Minn., one-half mile below lower end of Lanes Island (also known as Thompsons Island), about 300 meters back from left bank of river, one-half meter west of north and south fence, about 80 meters upstream from large square two-story house, in line with center of north and south road and 39 meters south from junction of fences at road. Road makes nearly a right angle at this point.

Elevation bolt in tile, 295.6918 meters, 970.126 feet.

Elevation cap on pipe, 296.9001 meters, 974.090 feet.

P. B. M. $2\frac{8}{8}^{1}$ is a tile and pipe, 5 miles above Monticello, Minn., about 400 meters above head of Island No. 163, about 600 meters back from left bank of river, in corner of fence on west side of north and south wagon road, on property of Henry Castle, 300 meters back from edge of timber.

Elevation bolt in tile, 295.2269 meters, 968.601 feet.

Elevation cap on pipe, 296.4383 meters, 972.575 feet.

P. B. M. $2\frac{8}{8}^{2}$ is a tile and pipe on public road, 300 meters back from left bank of river at foot of Bear Island (No. 161), one-half meter north of fence on south side of road through John Dyson's land, and 70 meters downstream from his house.

Elevation bolt in tile, 300.5088 meters, 985.930 feet.

Elevation cap on pipe, 301.7137 meters, 989.883 feet.

P. B. M. $2\frac{8}{8}^{3}$ is a tile and pipe in public road, about 1½ miles back from left bank of river, about 2½ miles above Bear Island, 42 meters down river from junction of roads, 33 meters down river from angle in fence, one-half meter north of wire fence, and about 250 meters down river from J. P. Anderson's house.

Elevation bolt in tile, 301.9640 meters, 990.704 feet.

Elevation cap on pipe, 303.1719 meters, 994.667 feet.

T. B. M. 87 is in public road, 1.4 miles above P. B. M. $2\frac{8}{8}^{3}$, being a nail in north root of 15-inch oak tree on south side of road in front of William White's residence, second tree east of gate in front of house, opposite a small lake on north side of road.

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Elevation, 304.5477 meters, 999.181 feet.

P. B. M. $^{2}\frac{1}{4}$ is a tile and pipe in public road, about three-fourths of a mile back from left bank of river, 3 miles below Clearwater, Minn., on south side of road, 1 meter west of fence corner on north and south section line between property of Barney Powers and property of B. H. Lee, about 200 meters below house.

Elevation bolt in tile, 304.9503 meters, 1000.502 feet.

Elevation cap on pipe, 306.1610 meters, 1004.474 feet.

P. B. M. $^{2}\frac{3}{4}$ is a tile and pipe opposite Clearwater, Minn., about 200 meters back from left bank of river, 200 meters above wagon road to ferry, on property of W. J. Kirk, 1½ meters west of fence running in northerly direction, and 32 meters south of fence corner. Blazed trees: 18-inch oak, 224°—7 meters; 15-inch oak, 249°—7.7 meters.

Elevation bolt in tile, 297.2782 meters, 975.331 feet.

Elevation cap on pipe, 298.4866 meters, 979.296 feet.

P. B. M. $^{2}\frac{5}{8}$ is a tile and pipe 3 miles above Clearwater, Minn., about 200 meters back from left bank of river at head of Island No. 151, on high ridge in jack oaks, about 100 meters upstream from edge of timber and cultivation, 16 meters downstream from east and west wire fence, and on south side of a very large ravine. Blazed trees: 4-inch oak, 19°—4.6 meters; 12-inch oak, 78°—12.9 meters; 15-inch oak, 319° 40′—20.1 meters.

Elevation bolt in tile, 311.1087 meters, 1,020.707 feet.

Elevation cap on pipe, 312.3154 meters, 1,024.666 feet.

P. B. M. $^{2}\frac{7}{8}$ is a tile and pipe on public road nearly due east of St. Augusta Church spire, one-half meter east of junction of fences on south side of road adjoining property of Mrs. Carrie Bowen, and about 150 meters north of her house.

Elevation bolt in tile, 313.9572 meters, 1,030.052 feet.

Elevation cap on pipe, 315.1614 meters, 1,034.003 feet.

P. B. M. $^{2}\frac{3}{8}$ is a tile and pipe 200 meters back from left bank of river at head of Island No. 139, about 2½ miles below Normal School building, in St. Cloud, Minn., on property of S. A. Gray, at corner of cultivated field and timber, on high ground, one-half meter south of east and west fence, and 27½ meters east of junction of fences. Blazed trees: 7-inch oak, 86°—8.6 meters; 9-inch oak, 146°—9.2 meters; 9-inch oak, 249°—6.5 meters.

Elevation bolt in tile, 318.8360 meters, 1,046.059 feet.

Elevation cap on pipe, 320.0421 meters, 1,050.016 feet.

P. B. M. $^{2}\frac{5}{8}$ is a tile and pipe in East St. Cloud, Minn., about 500 meters below upper wagon bridge, between Fourth and Fifth streets, on property of Mr. Wilson, 5 meters back from top of left bank of river, 15 meters south of a ravine, in scrub-oak timber. Blazed trees: 18-inch oak, 94°—3.2 meters; 24-inch oak, 242°—13.6 meters; 4-inch oak, 333°—3.8 meters.

Elevation bolt in tile, 314.6503 meters, 1,032.326 feet.

Elevation cap on pipe, 315.8589 meters, 1,036.292 feet.

P. B. M. St. Cloud is on Great Northern Railway Bridge over Mississippi River at St. Cloud, Minn., being a copper bolt leaded vertically into top of lower end of abutment at left-shore end of bridge, 27 inches back from face of abutment, and 24 inches from lower corner of abutment, and about 26 inches below top of rail.

Elevation, 320.9593 meters, 1,053.026 feet.

T. B. M. 110 is the highest point on granite bowlder, on top of left bank of Mississippi River, about 40 meters above a point opposite the mouth of Sauk River, 2 inches north of hole in bowlder where copper bolt was leaded by United States engineers from the St. Paul office. The copper bolt has been dug out, but T. B. M. 110 is practically at the same elevation.

Elevation, 312.3537 meters, 1,024.792 feet.

P. B. M. $^{2}\frac{9}{8}$ is a tile and pipe 1 mile above Sauk Rapids, Minn., 100 meters below foot of Clarks Island, directly opposite small towhead, in northwest corner of small cultivated field, at junction of fences, 15 meters back from left bank of river, and about 100 meters above a signboard on railroad which reads "Sauk Rapids One Mile." Blazed 5-inch oak, 160°—11 meters.

Elevation bolt in tile, 311.5143 meters, 1,022.038 feet.

Elevation cap on pipe, 312.7219 meters, 1,026.000 feet.

T. B. M. 112 is on Northern Pacific Railway, 350 meters above mile post 77 and about 200 meters below ⏃ Sauk Rapids; being the highest point on the bell of large cast iron drainpipe directly over mark cut thus ⋀; it is on the east end of the upper one of two drainpipes of opening under railroad.

Elevation 313.0747 meters, 1,027.157 feet.

P. B. M. $^{2}\frac{1}{8}$ is a tile and pipe about 4 miles above the town of Sauk Rapids, 150 meters back from left bank of river at foot of Wantab Rapids, in corner of fence on west side of public road, on property of J. K. Miller. East and west fence is Miller's south line, and is center line through sections 3 and 4. Blazed trees: 10-inch oak, 335°—9.1 meters; 9-inch oak, 21°—4.9 meters; 9-inch oak, 71°—1.5 meters.

Elevation bolt in tile, 318.8834 meters, 1,046.215 feet.

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Elevation cap on pipe, 320.0939 meters, 1,050.186 feet.

P. B. M. $\frac{2}{3}^{A}$ is a tile and pipe on public road, about 600 meters below large granite knob (known as Little Rock) on which is △ Wautab, about 600 meters back from left bank of river, on high ground back of cultivated field, 125 meters south of junction of fences, and one-half meter west of fence on west side of road. Blazed trees: 6-inch oak, 278°—4.5 meters; 6-inch oak, 308°—4 meters.

Elevation bolt in tile, 318.2722 meters, 1,044.209 feet.

Elevation cap on pipe, 319.4799 meters, 1,048.172 feet.

P. B. M. $\frac{2}{3}^{B}$ is a tile and pipe 10 meters back from left bank of river, about one-half mile above Brockaway Schoolhouse No. 7, 4 miles below Rice, Minn., on property of J. H. Anderson, and about 350 meters above his house, in open grassy spot, 73 meters below an east and west fence which runs to water's edge. Blazed trees: 15-inch oak, 197°—9 meters; 20-inch oak, 287½°—13.5 meters; 18-inch oak, 26°—4.9 meters.

Elevation bolt in tile, 320.4282 meters, 1,051.283 feet.

Elevation cap on pipe, 321.6390 meters, 1,055.256 feet.

P. B. M. △ Back Base (Rice Base Line) is a tile and pipe in open prairie 300 feet west of Northern Pacific Railway, 2 miles south of Rices Station, about 10 meters south of section line.

Elevation bolt in tile, 328.0445 meters, 1,076.271 feet.

Elevation cap on pipe, 329.2572 meters, 1,080.250 feet.

P. B. M. △ River Base (Rice Base Line) is a tile and pipe on left bank of river, in public road, about 2 miles below Rice, Minn., about one-half mile above ferry, and 8 meters below section line.

Elevation bolt in tile, 326.9484 meters, 1,072.675 feet.

Elevation cap on pipe, 328.1613 meters, 1,076.654 feet.

P. B. M. $\frac{2}{3}^{A}$ is a tile and pipe in public road 1½ miles below Rice, Minn., on high terrace about 200 meters back from left bank of river, 18 meters below junction of fences, one-half meter toward river from fence on north side of road adjoining property of Minneapolis Loan and Trust Company, 190 meters downstream from where road makes an angle and runs north to Rice. Log house stands near angle in road.

Elevation bolt in tile, 327.5580 meters, 1,074.675 feet.

Elevation cap on pipe, 328.7700 meters, 1,078.651 feet.

T. M. B. 129 is a nail in north root of 12-inch post oak in field, about 100 meters east of R. L. Russel's house, about 200 meters below road from Russel's Ferry to Rice, Minn.

Elevation, 326.8738 meters, 1,072.430 feet.

P. M. B. $\frac{2}{3}^{A}$ is a tile and pipe in public road, about 600 meters above Russels Ferry, which is due west of Rice, Minn., 400 meters back from left bank of river, one-half meter east of fence on west side of road, 100 meters above house of George P. McGee, who owns the property on east side of road; property on west side of road belongs to Robert Russel.

Elevation bolt in tile, 327.1366 meters, 1,073.292 feet.

Elevation cap on pipe, 328.3471 meters, 1,077.264 feet.

T. B. M. 133 is a nail in south root of 18-inch post oak on top of high bank on east side of Platte River, about 2 miles above P. B. M. $\frac{2}{3}^{A}$, 5 meters west of fence on west side of cultivated field, and about 200 meters below John Wilson's house.

Elevation, 331.5086 meters, 1,087.636 feet.

P. B. M. $\frac{2}{3}^{C}$ is a tile and pipe 50 meters back from left bank of river opposite head of Islands Nos. 88 and 89, about 1½ miles above mouth of Platte River, on property of J. H. Higgins and 230 meters downstream from his house, one-half meter south of east and west fence at edge of timber and cultivation. Blazed trees: 18-inch oak, 60°—10.6 meters; 18-inch oak, 102°—6.4 meters; 15-inch oak, 263°—5.6 meters.

Elevation bolt in tile, 324.7024 meters, 1,065.306 feet.

Elevation cap on pipe, 325.9105 meters, 1,069.270 feet.

P. B. M. $\frac{2}{3}^{Z}$ is a tile and pipe 300 meters back from left bank of river, opposite North Prairie, Minn., on top of high ridge in oak timber, 16 meters south of public road which runs from Royalton to North Prairie Ferry, about 100 meters back from corner of fence. Blazed trees: 15-inch oak stub, 129°—9.3 meters; 15-inch oak stub, 228°—13.4 meters.

Elevation bolt in tile, 330.9593 meters, 1,085.834 feet.

Elevation cap on pipe, 332.1719 meters, 1,089.813 feet.

P. B. M. $\frac{2}{3}^{B}$ is a tile and pipe opposite head of Island No. 77, about 1½ miles above wagon bridge over Mississippi River, known as the Royalton Bridge, on top of high terrace, about 400 meters back from left bank of river, on property of Peter McDougall and about 275 meters above his house, one-half meter west of a wire fence at edge of timber and cultivation. Blazed tree: 20-inch oak, 79° 25′—21.7 meters.

Elevation bolt in tile, 337.6581 meters, 1,107.812 feet.

Elevation cap on pipe, 338.8698 meters, 1,111.788 feet.

P. B. M. $\frac{2}{3}^{B}$ is a tile and pipe 11 meters back from left bank of river, 4½ miles above

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Royalton bridge, 450 meters below Cashs Island, 250 meters below Island No. 73, opposite lower end of cultivated field, about 20 meters below a bunch of white birch which stands at water's edge (only birch in this vicinity), in timber. Blazed trees: 18-inch oak, 20°—24.9 meters; 8-inch oak, 83°—9.3 meters; 12-inch oak, 274°—6.3 meters.

Elevation bolt in tile, 339.0878 meters, 1,112.503 feet.

Elevation cap on pipe, 340.2879 meters, 1,116.440 feet.

P. B. M. $\frac{3}{20}$ is a tile and pipe on left bank of river, 4 miles below Little Falls, Minn., at head of Island No. 64, on property of George Kruger and 30 meters below his house, 30 meters toward river from public road. Blazed trees: 18-inch oak, 76°—9 meters; 15-inch oak, 130°—9 meters.

Elevation bolt in tile, 342.4031 meters, 1,123.380 feet.

Elevation cap on pipe, 343.6060 meters, 1,127.326 feet.

P. B. M. $\frac{3}{21}$ is a tile and pipe 400 meters back from left bank of river, at head of Island No. 59, about three-fourths of a mile below Little Falls, Minn., on property of P. W. Hayes and on his south line, at junction of fences, about 200 meters west of public road, in pasture. Blazed trees: 18-inch oak, 266°—18.4 meters; 10-inch oak, 294°—15.4 meters; 12-inch oak, 125°—23.8 meters.

Elevation bolt in tile, 345.2608 meters, 1,132.756 feet.

Elevation cap on pipe, 346.4712 meters, 1,136.727 feet.

T. B. M. 152 is in Little Falls, Minn., on Hotel Buckman, at southeast corner of First street and First avenue, south, being a square cut in top of lower step at First street entrance to hotel, 6 inches above sidewalk and 34 inches south of northwest corner of hotel, marked U. □ S.

Elevation, 345.6964 meters, 1,134.185 feet.

P. B. M. $\frac{3}{22}$ is a tile and pipe 5 meters back from top of left bank of river, about 1 mile above railroad bridge over Mississippi River at Little Falls, Minn., in open place in timber opposite entrance to fair grounds, 200 meters below foot of large island; a wagon road is cut down to river in front of benchmark. Blazed trees: 5-inch oak, 89°—7.9 meters; 8-inch oak, 248°—21.6 meters; 8-inch oak, 294°—22.5 meters.

Elevation bolt in tile, 347.1058 meters, 1,138.809 feet.

Elevation cap on pipe, 348.3026 meters, 1,142.735 feet.

P. B. M. $\frac{3}{23}$ is a tile and pipe in public road at Belle Prairie Church, 4¼ miles above Little Falls, Minn., 300 meters back from left bank of river, three-fourths of a meter west of fence on east side of road, 17 meters north of junction of fences, and 44 meters north from line of north wall of Belle Prairie Church. Blazed tree: 18-inch oak, 259°—1.9 meters.

Elevation bolt in tile, 350.0824 meters, 1,148.575 feet.

Elevation cap on pipe, 351.2947 meters, 1,152.552 feet.

P. B. M. $\frac{3}{24}$ is a tile and pipe in public road 3 miles above Belle Prairie Church, about 500 meters back from left bank of river, opposite foot of Island No. 45, one-half meter east of fence on west side of road, 2 meters south of fence corner, 15 meters south of Leon Bellefenil's house. Blazed tree: 20-inch oak, 306°—24 meters.

Elevation bolt in tile, 352.4012 meters, 1,156.182 feet.

Elevation cap on pipe, 353.6116 meters, 1,160.154 feet.

P. B. M. $\frac{3}{25}$ is a tile and pipe 300 meters back from left bank of river, 4½ miles below ferry at Fort Ripley, Minn., one-half mile below foot of Island No. 38, opposite point where timber commences along river, on property of D. Brauchaud and about 600 meters below his house, one-half meter east of north and south fence, 8 meters south of junction of fences, 100 meters above upper one of two lone pine trees which stand in cultivated field. Blazed tree: 10-inch oak, 304°—4.4 meters.

Elevation bolt in tile, 354.4513 meters, 1,162.908 feet.

Elevation cap on pipe, 355.6660 meters, 1,166.894 feet.

P. B. M. $\frac{3}{26}$ is a tile and pipe in north and south wagon road 500 meters back from left bank of river, 1½ miles below Fort Ripley ferry, opposite foot of Island No. 24, 500 meters below J. F. Kimball's house; adjoining property belongs to W. A. Clark, three-fourths of a meter from fence on west side of road, 125 meters south of junction of fences. Blazed tree: 7-inch oak, 229°—3 meters.

Elevation bolt in tile, 356.9822 meters, 1,171.212 feet.

Elevation cap on pipe, 358.1992 meters, 1,175.205 feet.

P. B. M. $\frac{3}{27}$ is a tile and pipe on right of way of Northern Pacific Railway, about 1 mile above Fort Ripley station, about 150 meters above railroad bridge over Nocosippi River, one-half meter west of fence on east side of track, 8 meters south of line of south wall of house on opposite side of track. Blazed tree: 8-inch oak, 281°—5.2 meters. Southeast corner of house, 74° 26′—54.2 meters.

Elevation bolt in tile, 359.9706 meters, 1,181.017 feet.

Elevation cap on pipe, 361.1852 meters, 1,185.001 feet.

P. B. M. $\frac{3}{28}$ is a tile and pipe 3 miles above Old Fort Ripley, one-half meter east of an old fence on top of left bank of river, opposite a lone 30-inch elm snag which stands on top of right bank, 200 meters above a large bunch of small pines standing near river, directly back of an 18-inch Norway pine which stands on slope of river

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bank and is the only one in the vicinity. Blazed trees: 18-inch Norway pine, 110°—6.2 meters; 10-inch jack pine, 38°—7.5 meters.

Elevation bolt in tile, 359.7840 meters, 1,180.404 feet.

Elevation cap on pipe, 360.9947 meters, 1,184.376 feet.

P. B. M. $\frac{29}{2}$ is a tile and pipe 300 meters back from left bank of river, about 200 meters above Island No. 22, on property of George Smith and 170 meters downstream from his house, in pasture, one-half meter west of north and south fence, 50 meters north of fence corner. Blazed tree: Lone 8-inch oak, 214°—11.6 meters.

Elevation bolt in tile, 366.9857 meters, 1,204.032 feet.

Elevation cap on pipe, 368.1960 meters, 1,208.003 feet.

P. B. M. $\frac{3}{4}$ is a tile and pipe on left bank of river near Old Crow Wing Ferry, about opposite upper mouth of Crow Wing River, on property of Charles Bailey, 15 meters north from corner of timber, 75 meters back from crest of high ridge. Mr. Bailey's house stands south 20° east (magnetic bearing) about 250 meters. Blazed trees: 10-inch oak, 182°—13.1 meters; 8-inch oak, 342°—6.3 meters.

Elevation bolt in tile, 368.0038 meters, 1,207.372 feet.

Elevation cap on pipe, 369.2145 meters, 1,211.344 feet.

P. B. M. $\frac{31}{4}$ is a tile and pipe 3 miles above Old Crow Wing Ferry, on top of high ridge, 20 meters back from water's edge on left bank of river, 500 meters below a cultivated field on right bank, low ground along river on both sides of benchmark; an 18-inch Norway pine stands on slope of bank 5 meters downstream and a dead snag stands 30 meters upstream on slope of bank. Blazed trees: 15-inch white pine, 6°—6 meters; 18-inch Norway pine, 124°—11.2 meters.

Elevation bolt in tile, 364.9946 meters, 1,197.500 feet.

Elevation cap on pipe, 366.2046 meters, 1,201.470 feet.

P. B. M. $\frac{32}{1}$ is a tile and pipe on left bank of river 3½ miles below railroad bridge at Brainerd, Minn., 100 meters below mouth of Buffalo Creek, 50 meters above head of island, on top of ridge, 30 meters back from water's edge, about 50 meters above a mound. Blazed trees: 8-inch jack pine, 291°—4.8 meters; 10-inch jack pine, 344°—3.9 meters; 8-inch jack pine, 85°—5.9 meters.

Elevation bolt in tile, 369.5155 meters, 1,212.332 feet.

Elevation cap on pipe, 370.7241 meters, 1,216.297 feet.

T. B. M. 195 is the highest point, on large granite bowlder, about 2 meters east of Northern Pacific Railway track, 2¼ miles below Brainerd, Minn., one-fourth mile above milepost 3, and just below road crossing.

Elevation, 383.5632 meters, 1,258.421 feet.

T. B. M. 196 is on Northern Pacific Railway right of way, 1¼ miles below Brainerd, Minn., one-half mile below milepost 1, being a square cut on highest point of large granite bowlder 5 meters east of track, 6 inches north of hole in top of bowlder, at south end of railroad cut.

Elevation, 378.6376 meters, 1,242.260 feet.

P. B. M. $\frac{33}{2}$ is a tile and pipe in Brainerd, Minn., on top of high bank, about 600 meters below lower wagon bridge over Mississippi River, 300 meters back from left bank of river, at corner of fence near southwest corner of Third and Quince streets, 5 meters north of south line of Quince street, 40 meters north of George Sargent's house and 1 meter northwest of northeast corner of his lot.

Elevation bolt in tile, 376.7972 meters, 1,236.222 feet.

Elevation cap on pipe, 378.0065 meters, 1,240.190 feet.

P. B. M. "Sanitarium" is in Brainerd, Minn., in southeast corner of Sanitarium (Northern Pacific Railway Hospital) grounds, on right bank of river, at west end of Northern Pacific Railway Bridge over Mississippi River, two meters from east fence and 5 meters from south fence around Sanitarium grounds; established under the direction of United States engineer office at St. Paul, Minn. It is the head of a copper bolt in stone 16 inches square and 6 inches thick, sunk 4 feet in ground and surmounted by an iron pipe 4 inches in diameter and 4 feet long, with cast-iron cap at surface of ground marked with letters "U. S. E. B. M."

Elevation bolt in tile, 374.5545 meters, 1,228.864 feet.

Elevation cap on pipe, 375.7975 meters, 1,232.942 feet.

P. B. M. Ⓢ South Base (Brainerd Base Line) is a tile and pipe on south side of jack-pine grove, 20 meters from edge of high ground, and on prolongation of north and south street (Mill street) leading south from sawmill in northeast Brainerd. Supposed to be in alley of a newly surveyed addition, about 20 feet east of line of ditch running south across meadow lands. Blazed trees: 8-inch jack pine, 188°—11.2 meters; 6-inch jack pine, 261°—15.1 meters.

Elevation bolt in tile, 375.8285 meters, 1,233.044 feet.

Elevation cap on pipe, 377.0406 meters, 1,237.021 feet.

P. B. M. Ⓝ North Base (Brainerd Base Line) is a tile and pipe in center of Mill street in northeast Brainerd, about 150 meters from left bank of river, 11 meters nearly south of switch block on Brainerd and Northern Minnesota Railway, 40 meters northeast of road crossing, and opposite east and west roadway through Brainerd Lumber Company's lumber yard.

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Elevation bolt in tile, 373.1287 meters, 1,224.187 feet.
Elevation cap on pipe, 374.3425 meters, 1,228.169 feet.
P. B. M. $2\frac{1}{2}^{A}$ is a tile and pipe in northeast Brainerd, Minn., 25 meters back from left bank of river, in front of X I W sawmill, 25 meters toward river from railroad track, and about 250 meters below end of railroad bridge. Blazed tree: Norway pine, 166° 15′—20.5 meters; ⓐ North Base, 17° 33′—163.8 meters.
Elevation bolt in tile, 373.6330 meters, 1,225.841 feet.
Elevation cap on pipe, 374.8412 meters, 1,229.805 feet.
P. B. M. $2\frac{1}{2}^{B}$ is a tile and pipe on left bank of river 3 miles above sawmill in northeast Brainerd, Minn., on ridge about 44 feet above water surface, one-half mile above point where river narrows up, 200 meters above a high wooded point (150 feet high), directly back of low point of land, 100 meters above a bay on right bank, and 75 meters back from water's edge. Blazed trees: Jack pine, 181°—12.7 meters; jack pine, 317°—5.4 meters; jack pine, 23°—10.6 meters.
Elevation bolt in tile, 376.7286 meters, 1,235.997 feet.
Elevation cap on pipe, 377.9419 meters, 1,239.978 feet.
T. B. M. 210 is top of 8-inch boat spike in top of 22-inch Norway pine stump 10 meters west of P. B. M. $2\frac{1}{2}^{B}$; stump is burned on north side.
Elevation, 376.5606 meters, 1,235.446 feet.
T. B. M. 211 is a twenty-penny wire nail in west root of 15-inch jack pine 5 meters east of P. B. M. $2\frac{1}{2}^{B}$, one of the witness trees for the P. B. M.
Elevation, 377.6105 meters, 1,238.891 feet.
T. B. M. 264 is about one-half mile back of Markey's house, on right bank of river, just above ⓐ Parker, about 5 miles above Brainerd, Minn., being a nail in root of 12-inch jack pine at junction of road from Markey's with main road, just above a vacant house. Tree marked with letters.
Elevation, 377.8347 meters, 1,239.626 feet.
T. B. M. 212 is on top of left bank of river about 600 meters above mouth of Rabbit River, in front of P. B. M. $2\frac{1}{2}^{I}$, being a nail in east root of 10-inch jack pine.
Elevation, 378.1392 meters, 1,240.625 feet.
P. B. M. $2\frac{1}{2}^{I}$ is a tile and pipe about 600 meters above the mouth of Rabbit River, on left bank about 65 meters back from top of bank, surrounded by three large white pines, about 100 meters above Island No. 4 and about 40 meters upstream from highest point of ridge. Blazed trees: 36-inch white pine, 240°—10.3 meters; 24-inch white pine, 331°—2.9 meters; 36-inch white pine, 49°—13.5 meters.
Elevation bolt in tile, 374.6177 meters, 1,229.170 feet.
Elevation cap on pipe, 375.8535 meters, 1,233.126 feet.
T. B. M. 212A is a thirty-penny wire nail in east root of 36-inch white pine 13.5 meters south of P. B. M. $2\frac{1}{2}^{I}$.
Elevation, 375.8515 meters, 1,233.120 feet.
P. B. M. $2\frac{1}{2}^{H}$ is a tile and pipe 3¼ miles above the mouth of Rabbit River, on top of high ridge, 100 meters back from water's edge on left bank of river, 75 meters above point where ridge leaves the river, one-half mile below Half Moon Marsh, in Sec. 1, T. 47 N., R. 30 W., of fourth principal meridian, near a Norway pine on top of ridge. Blazed trees: Norway pine, 91°—16.3 meters; 20-inch white pine, 186°—37 meters.
Elevation bolt in tile, 381.0616 meters, 1,260.056 feet.
Elevation cap on pipe, 385.2685, 1,264.016 feet.
P. B. M. $2\frac{1}{2}^{F}$ is a tile and pipe 30 meters back from left bank of river, 500 meters above Dr. Camp's house (Old Indian Mission), in timber, 75 meters below mouth of slough on right bank. Blazed trees: 15-inch basswood, 257°—1.5 meters; 12-inch ash, 348°—5.5 meters; 18-inch ash, 75°—8.6 meters.
Elevation bolt in tile, 365.5359 meters, 1,199.276 feet.
Elevation cap on pipe, 366.7446 meters, 1,203.241 feet.
T. B. M. 223 is on left bank of river 2 meters from water's edge, at point where bluff leaves the river, about 1,200 meters above P. B. M. $2\frac{1}{2}^{F}$, being a ten-penny wire nail in root of 10-inch cottonwood tree marked B. M. on river side.
Elevation, 365.3933 meters, 1,198.808 feet.
T. B. M. 225 is on left bank of river 1¼ miles above Dr. Camp's house (Old Indian Mission), 10 meters above point where bluff leaves the river, being a 5-inch boat spike in 8-inch ash tree 5 meters from water's edge; tree marked B. M. on river side.
Elevation, 365.6681 meters, 1,199.709 feet.
P. B. M. $2\frac{1}{2}^{G}$ is a tile and pipe on left bank of river 1½ miles below mouth of Pine River, 1 mile above Foster's house, on north slope of ridge, 5 meters back from bank of river, 25 meters upstream from highest point of ridge, in section 17, about one-fourth mile north of south line. Blazed trees: 6-inch Norway pine, 185°—9.6 meters; 10-inch white pine, 268°—9.6 meters; 6-inch Norway pine, 237°—3.2 meters.
Elevation bolt in tile, 370.6408 meters, 1,216.024 feet.
Elevation cap on pipe, 371.8504 meters, 1,219.992 feet.
P. B. M. $2\frac{1}{2}^{L}$ is a tile and pipe on left bank of river 2½ miles above mouth of Pine River, 1 mile below Island Lake, 35 meters back from top of bank, 75 meters below high ridge, 2 meters west of wagon road, in section 15. Blazed trees: 8-inch ash, 195°—15.3 meters; 24-inch oak, 236°—34.2 meters; 24-inch oak, 336°—15 meters.

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Elevation bolt in tile, 368.5431 meters, 1,209.142 feet.

Elevation cap on pipe, 369.7470 meters, 1,213.092 feet.

P. B. H. $\frac{3}{4}^{12}$ is a tile and pipe 54 meters back from left bank of river, about three-fourths of a mile below Towhead Rapids, in section 24, about one-fourth of a mile west of township line, on first bench back from river, opposite a point where high sand bank strikes river, near two 24-inch white pines standing northeast. Blazed trees: 24-inch white pine, 302°—6.3 meters; 18-inch white pine, 59°—15.7 meters; 12-inch white pine, 148°—15.2 meters.

Elevation bolt in tile, 370.3287 meters, 1,215.000 feet.

Elevation cap on pipe, 371.5396 meters, 1,218.973 feet.

P. B. M. $\frac{3}{4}^{13}$ is a tile and pipe on left bank of river about 25 meters above head of Island No. 1, 5 meters back from top of high bank, 15 meters from water's edge, 15 meters downstream from small ravine. Blazed trees: 15 inch white pine, 62° 20′—21 meters; 6-inch white pine, 179°—10.6 meters.

Elevation bolt in tile, 373.8269 meters, 1,226.477 feet.

Elevation cap on pipe, 375.0383 meters, 1,230.452 feet.

P. B. M. $\frac{3}{4}^{14}$ is a tile and pipe on left bank of river, 1½ miles above Dean Brook, on top of high bank 8 meters back from top, at east edge of cultivated field, 200 meters below house on right bank, in section 2. Blazed trees: 7-inch jack pine, 278°—9 meters; 10-inch jack pine, 217°—1.6 meters.

Elevation bolt in tile, 375.4597 meters, 1,231.834 feet.

Elevation cap on pipe, 376.6699 meters, 1,235.805 feet.

P. B. M. $\frac{3}{4}^{15}$ is a tile and pipe on left bank of river, 250 meters above mouth of Hay Creek, on high ground 75 meters back from river, on property of John Doteler, near fence which is the line between John Doteler and Frank Doteler; 339° 7′—65.1 meters to northwest corner of Frank Doteler's house.

Elevation bolt in tile, 373.6236 meters, 1,225 810 feet.

Elevation cap on pipe, 374.8329 meters, 1,229.778 feet.

T. B. M. 251 is in public road on left bank of river, 50 meters below bridge over Cedar Brook, 15 meters from river bank, being a nail in root on river side of 2½-foot elm tree.

Elevation, 371.2845 meters, 1,218.136 feet.

P. B. M. $\frac{3}{4}^{16}$ is a tile and pipe about 600 meters above mouth of Cedar Brook, in cultivated field, just inside of fence on south side of public road, 35 meters below junction of fences, 50 meters back from left bank of river, on property of D. McGillis estate, 100 meters above house and on same side of road.

Elevation bolt in tile, 371.2173 meters, 1,217.915 feet.

Elevation cap on pipe, 372.4282 meters, 1,221.888 feet.

P. B. M. $\frac{3}{4}^{17}$ is a tile and pipe 3 miles below Aitkin, Minn., on property of Conrad Schwab and about 50 meters southeast of his house, 75 meters back from left bank of river, 3 meters east of small ditch, 3 meters west of fence, in section 15. Blazed trees: 36-inch basswood, 39°—23.1 meters; 8-inch basswood, 105°—3.5 meters; 15-inch ash, 173°—5.3 meters.

Elevation bolt in tile, 371.3552 meters, 1,218.368 feet.

Elevation cap on pipe, 372.5613 meters, 1,222.325 feet.

T. B. M. 259 is in Aitkin, Minn., being a 20-penny wire nail in northwest root of 20-inch white pine tree standing in street near southwest corner of Aitkin County court-house yard; nail is 1 meter from tree, 2 meters south of fence, and 6 meters east of fence corner.

Elevation, 374.3109 meters, 1,228.065 feet.

P. B. M. "Court House" is in Aitkin, Minn., being a horizontal furrow in copper bolt leaded into second course of brick above foundation at southwest corner of L on south side of Aitkin County court-house, 8 inches east of corner and 4 feet above ground. Court-house built in 1888. Marked U. ⊖ S. P. B. M.

Elevation, 376.7681 meters, 1,236.127 feet.

P. B. M. $\frac{3}{4}^{18}$ is a tile and pipe in Aitkin, Minn., in cultivated field, one-half meter west of fence on west side of street leading to wagon bridge over Mississippi River, 11 meters south of fence corner on property of Hodgeden and McDonald, and about 75 meters back from left bank of river.

Elevation bolt in tile, 371.2985 meters, 1,218.182 feet.

Elevation cap on pipe, 372.5095 meters, 1,222.155 feet.

T. B. M. 273 is a wire nail in east root of 2½-foot elm tree, about 3 meters south of ⓐ Lower Base, Aitkin Base Line.

Elevation, 372.3065 meters, 1,221.489 feet.

P. B. M. ⓐ Lower Base (Aitkin Base Line) is a tile and pipe, about 20 meters back from left bank of river, about 1,500 meters above wagon bridge over Mississippi River at Aitkin, Minn., at extreme lower end of point of timber, on line with east and west road, 650 meters west of angle in road at township line, one-fourth of a mile south of section line between sections 13 and 24.

Elevation bolt in tile, 371.3653 meters, 1,218.401 feet.

Elevation cap on pipe, 372.5787 meters, 1,222.382 feet.

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898.*

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. 65 (Ferguson, 1891)												223.8444	734.404
T. B. M. 1 (Ferguson, 1891)	P. B. M. 65	12	0.012	Direct	+ 680.8	+ 0.20	+ 0.20	— 0.20	0.13	0.1	+ 0.1	224.5255	736.639
				Reverse	+ 681.2	— .20							
					+ 681.0								
P. B. M. 67	T. B. M. 1	591	.603	Direct	— 2,457.5	— .25	— .05	+ .05	.17	.2	— .2	222.0675	728.574
				Reverse	— 2,458.0	+ .25							
					— 2,457.75								
P. B. M. 68	P. B. M. 67	426	1.029	Direct	— 1,645.5	— .40	— .45	+ .45	.27	.3	— .4	220.4214	723.174
				Reverse	— 1,646.3	+ .40							
					— 1,645.9								
P. B. M. 70	P. B. M. 68	59	1.088	Direct	+ 446.2	+ .25	— .20	+ .20	.17	.4	— .3	220.8679	724.639
				Reverse	+ 446.7	— .25							
					+ 446.45								
Old U. S. B. M. "A"	P. B. M. 70	59	1.147	Direct	+ 770.0	— .20	— .40	+ .40	.13	.4	— .2	221.6378	727.165
				Reverse	+ 769.6	+ .20							
T. B. M. 24	T. B. M. 1 (Ferguson, 1891).	1,386	1.898	Direct	+11,539.7	+ 1.30	+ 1.50	— 1.50	.87	.9	+ 1.6	236.0680	.....
				Reverse	+11,542.3	— 1.30							
					+11,541.0								
T. B. M. 23	T. B. M. 24	1,659	3.057	Direct	+18,622.8	+ 1.20	+ 2.70	— 2.70	.80	1.2	+ 3.7	254.6941	835.618
				Reverse	+18,625.2	— 1.20							
					+18,624.0								
T. B. M. 22	T. B. M. 23	352	3.409	Direct	+ 3,858.7	— .20	+ 2.50	— 2.50	.13	1.2	+ 4.2	258.5532	848.279
				Reverse	+ 3,858.3	+ .20							
					+ 3,858.5								

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T. B. M. 21	T. B. M. 22	1,508	4.917	Direct	+18,528.0	− .40	+2.10	−2.10	.27	1.2	+ 6.4	277.0830	
				Reverse	+18,527.2	+ .40							
					+18,527.6								
T. B. M. 20	T. B. M. 21	976	5.893	Direct	+10,813.8	+ 1.75	+ 3.85	− 3.85	1.17	1.7	+ 7.7	287.8998	
				Reverse	+10,817.3	− 1.75							
					+10,815.55								
T. B. M. 19	T. B. M. 20	720	6.613	Direct	+ 3,421.3	+ 1.10	+ 4.95	− 4.95	.73	1.8	+ 8.1	291.3226	
				Reverse	+ 3,423.5	− 1.10							
					+ 3,422.4								
P. B. M. Macalester bolt in tile.	T. B. M. 19	18	6.631	Direct	− 844.0	− .15	+ 4.80	− 4.80	.10	1.8	+ 8.0	290.4784	953.022
				Reverse	− 844.3	+ .15							
					− 844.15								
P. B. M. Macalester cap on pipe.	T. B. M. 19	18	6.631	Direct	+ 365.3	.00	+ 4.95	− 4.95	.00	1.6	+ 8.1	291.6879	956.990
				Reverse	+ 365.3	.00							
					+ 365.3								
T. B. M. 18	T. B. M. 19	1,600	8.218	Direct	− 8,163.2	+ 1.20	+ 6.15	− 6.15	.80	2.0	+ 7.1	283.1596	929.010
				Reverse	− 8,160.8	− 1.20							
					− 8,162.0								
T. B. M. 17	T. B. M. 18	142	8.355	Direct	− 315.3	− .35	+ 5.80	− 5.80	.23	2.0	+ 7.1	282.8439	
				Reverse	− 316.0	+ .35							
					− 315.65								
T. B. M. 16	T. B. M. 17	1,404	9.759	Direct	−11,718.8	+ .25	+ 6.05	− 6.05	.17	2.0	+ 5.7	271.1240	889.522
				Reverse	−11,718.3	− .25							
					−11,718.55								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	B ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 13	T. B. M. 14	1,883	13.543	Direct	+ 2,989.8	+ 1.45	+ 7.20	— 7.20	0.97	2.3	+ 4.6	262.3066	860.594
				Reverse	+ 2,992.7	— 1.45							
					+ 2,991.25								
P. B. M., University campus	T. B. M. 13	184	13.727	Direct	+ 702.2	— .10	+ 7.19	— 7.19	.07	2.3	+ 4.7	263.0087	862.897
				Reverse	+ 702.0	+ .10							
					+ 702.1								
P. B. M., Pillsbury Hall	P. B. M., University campus.	195	13.922	Direct	+ 1,653.9	+ .30	+ 7.49	— 7.49	.20	2.3	+ 4.9	264.6631	868.325
				Reverse	+ 1,654.5	— .30							
					+ 1,654.2								
T. B. M. 12	T. B. M. 13	599	14.142	Direct	— 3,665.3	— .10	+ 7.10	— 7.10	.07	2.3	+ 4.2	258.6407	848.566
				Reverse	— 3,665.5	+ .10							
					— 3,665.4								
P. B. M. 2¾ᵃ; bolt in tile	T. B. M. 12	295	14.437	Direct	—10,392.0	— .35	+ 6.75	— 6.75	.23	2.3	+ 2.9	248.2471	814.466
				Reverse	—10,392.7	+ .35							
					—10,392.35								
P. B. M. 2¾ᵃ; cap on pipe	P. B. M. 2¾ᵃ	66	14.503	Direct	+ 1,212.7	+ .05	+ 6.80	— 6.80	.03	2.3	+ 3.1	249.4601	818.446
				Reverse	+ 1,212.8	— .05							
					+ 1,212.75								
P. B. M., Great Northern (Minneapolis.)	T. B. M. 12	1,585	15.727	Direct	+ 5,962.0	+ .15	+ 7.25	— 7.25	.10	2.3	+ 4.9	264.6036	868.130
				Reverse	+ 5,962.3	— .15							
					+ 5,962.15								
P. B. M., brewery office	P. B. M., Great Northern.	1,655	17.382	Direct	— 9,617.0	+ .10	+ 7.35	— 7.35	.07	2.3	+ 3.7	254.9855	836.574
				Reverse	— 9,616.8	— .10							
					— 9,616.9								

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					+ 3,466.5	+ .40	+ 7.75	− 7.75	.27	2.3	+ 4.2	258.4529	847.950	
					+ 3,467.3	− .40								
T. B. M. 11	P. B. M., brewery office.	653	18.037	Direct..... Reverse.....	+ 3,466.9									
					+ 210.0	− .50	+ 7.25	− 7.25	.33	2.3	+ 4.2	258.6624	.....	
T. B. M. A	T. B. M. 11	704	18.741	Direct..... Reverse.....	+ 209.0	+ .50								
					+ 209.5									
					+ 903.2	− .10	+ 7.15	− 7.15	.07	2.3	+ 4.3	259.5656	851.601	
P. B. M., Gluck	T. B. M. A	166	18.907	Direct..... Reverse.....	+ 903.0	+ .10								
					+ 903.1									
					+ 1,352.8	− .40	+ 7.35	− 7.35	.27	2.3	+ 4.3	259.8054	852.387	
T. B. M. 1	T. B. M. 11	1,587	19.624	Direct..... Reverse.....	+ 1,352.0	+ .40								
					+ 1,352.4									
					− 592.3	.00	+ 7.35	− 7.35	.00	2.3	+ 4.2	259.2130	850.444	
P. B. M. 2[3]; bolt in tile	T. B. M. 1	138	19.762	Direct..... Reverse.....	− 592.3	.00								
					− 592.3									
					+ 621.5	− .50	+ 6.85	− 6.85	.33	2.3	+ 4.4	260.4265	854.425	
P. B. M. 2[3]; cap on pipe	do	138	19.762	Direct..... Reverse.....	+ 620.5	+ .50								
					+ 621.0									
					− 616.5	− .10	+ 7.25	− 7.25	.07	2.3	+ 4.2	259.1887	.....	
T. B. M. 2	T. B. M. 1	2,490	22.114	Direct..... Reverse.....	− 616.7	+ .10								
					− 616.6									
					+ 942.5	− .10	+ 7.15	− 7.15	.07	2.3	+ 4.4	260.1313	853.457	
T. B. M. 3	T. B. M. 2	315	22.429	Direct..... Reverse.....	+ 942.3	+ .10								
					+ 942.4									
					− 351.7	− .25	+ 6.90	− 6.90	.17	2.3	+ 4.3	259.7793	852.802	
T. B. M. 4	T. B. M. 3	981	23.410	Direct..... Reverse.....	− 352.2	+ .25								
					− 351.95									
					+ 70.0	− 1.75	+ 5.15	− 5.15	1.17	2.6	+ 4.3	259.8475	852.526	
T. B. M. 5	T. B. M. 4	1,644	25.054	Direct..... Reverse.....	+ 66.5	+ 1.75								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r±.	R±.	Rod correction.	Elevation above Cairo datum.	
							Direct line.	Reverse line.					
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. 2 6/7; bolt in tile	T. B. M. 5	325	26.379	Direct	— 187.7	— 0.25	+ 4.90	— 4.90	0.17	2.6	+ 4.3	259.6595	851.909
				Reverse	— 188.2	+ .25							
					— 187.95								
P. B. M. 2 1/2; cap on pipe	P. B. M. 2 1/2	257	26.636	Direct	+ 1,207.2	— .20	+ 4.70	— 4.70	.13	2.6	+ 4.4	260.8666	855.869
				Reverse	+ 1,206.8	+ .20							
					+ 1,207.0								
T. B. M. 6	T. B. M. 5	1,474	28.528	Direct	+ 3,572.7	— .45	+ 4.70	— 4.70	.30	2.6	+ 4.8	263.4202	864.247
				Reverse	+ 3,571.8	+ .45							
					+ 3,572.25								
T. B. M. 7	T. B. M. 6	589	27.117	Direct	— 1,806.2	— .55	+ 4.15	— 4.15	.37	2.6	+ 4.5	261.6132	858.319
				Reverse	— 1,807.3	+ .55							
					— 1,806.75								
T. B. M. 8	T. B. M. 7	928	28.045	Direct	— 1,141.5	— .85	+ 3.30	— 3.30	.57	2.7	+ 4.4	260.4708	854.571
				Reverse	— 1,143.2	+ .85							
					— 1,142.35								
T. B. M. 9	T. B. M. 8	1,450	29.495	Direct	+ 6,634.2	— .50	+ 2.80	— 2.80	.33	2.7	+ 5.2	267.1052	876.337
				Reverse	+ 6,633.2	+ .50							
					+ 6,633.7								
P. B. M. 2 5/8; bolt in tile	T. B. M. 9	693	30.188	Direct	— 2,682.7	— .25	+ 2.55	— 2.55	.17	2.7	+ 4.9	264.4220	867.534
				Reverse	— 2,683.2	+ .25							
					— 2,682.95								
P. B. M. 2 3/4; cap on pipe	P. B. M. 2 3/4	42	30.230	Direct	+ 1,211.5	+ .40	+ 2.95	— 2.95	.27	2.7	+ 5.0	265.6340	871.510
				Reverse	+ 1,212.3	— .40							
					+ 1,211.9								

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T. B. M. 10	T. B. M. 9	760	30.255	Direct	+ 1,187.0	.....	+ 2.80	— 2.80	.....	2.7	+ 5.3	268.2923	330.282
				Reverse	+ 1,187.0	.....							
					+ 1,187.0								
T. B. M. 25	T. B. M. 10	1,466	31.721	Direct	+ 560.3	— .50	+ 2.30	— 2.30	.33	2.7	+ 5.4	268.8522	.....
				Reverse	+ 559.3	+ .50							
					+ 559.8								
T. B. M. 26	T. B. M. 25	1,177	32.898	Direct	+ 5,756.3	+ .10	+ 2.40	— 2.40	.07	2.7	+ 6.1	274.6093	900.957
				Reverse	+ 5,756.5	— .10							
					+ 5,756.4								
T. B. M. 27	T. B. M. 26	1,431	34.329	Direct	+ 2,129.3	— .25	+ 2.15	— 2.15	.17	2.8	+ 6.3	276.7386	907.943
				Reverse	+ 2,128.8	+ .25							
					+ 2,129.05								
ⓐ Dunn; bolt in tile	T. B. M. 27	406	34.735	Direct	— 3,192.5	+ .50	+ 2.65	— 2.65	.33	2.8	+ 6.0	273.5463	897.470
				Reverse	— 3,191.5	— .50							
					— 3,192.0								
ⓐ Dunn; cap on pipe	ⓐ Dunn	193	34.928	Direct	+ 1,214.8	— .25	+ 2.40	— 2.40	.17	2.8	+ 6.1	274.7609	901.454
				Reverse	+ 1,214.3	+ .25							
					+ 1,214.55								
T. B. M. 28	T. B. M. 27	934	35.263	Direct	— 4,208.8	+ 1.40	+ 3.55	— 3.55	.93	2.9	+ 5.8	272.5307	.....
				Reverse	— 4,206.0	— 1.40							
					— 4,207.4								
T. B. M. 29	T. B. M. 28	850	36.113	Direct	— 5,602.3	+ .05	+ 3.60	— 3.60	.03	2.9	+ 5.2	266.9278	875.755
				Reverse	— 5,602.2	— .05							
					— 5,602.25								
T. B. M. 30	T. B. M. 29	983	37.096	Direct	+ 2,221.7	+ .15	+ 3.75	— 3.75	.10	2.9	+ 5.4	269.1499	883.046
				Reverse	+ 2,222.0	— .15							
					+ 2,221.85								
P. B. M. $\frac{9}{32}$; bolt in tile	T. B. M. 30	901	37.997	Direct	— 8,370.5	— .35	+ 3.40	— 3.40	.23	2.9	+ 4.4	260.7780	855.578
				Reverse	— 8,371.2	+ .35							
					— 8,370.85								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. $\frac{2}{2}$^{2}; cap on pipe.....	P. B. M. $\frac{2}{2}$^{0}	154	38.151	Direct.....	+ 1,205.5	— 0.35	+ 3.05	— 3.05	0.23	2.9	+ 4.6	261.9834	859.533
				Reverse.....	+ 1,204.8	+ .35							
					+ 1,205.15								
T. B. M. 31	T. B. M. 30	807	37.903	Direct.....	+ 170.8	+ 1.70	+ 5.45	— 5.45	1.13	3.1	+ 5.5	269.3225	.....
				Reverse.....	+ 174.2	— 1.70							
					+ 172.50								
T. B. M. 32	T. B. M. 31	1,830	39.733	Direct.....	+ 2,281.0	+ .40	+ 5.85	— 5.85	.27	3.1	+ 5.7	271.6041	.....
				Reverse...	+ 2,281.8	— .40							
					+ 2,281.4								
Ⓐ Powell; bolt in tile.....	T. B. M. 32	40	39.773	Direct.....	— 1,032.7	+ .10	+ 5.95	— 5.95	.07	3.1	+ 5.6	270.5714	887.709
				Reverse.....	— 1,032.5	— .10							
					— 1,032.6								
Ⓐ Powell; cap on pipe	T. B. M. 32	40	39.773	Direct.....	+ 182.3	— .15	+ 5.70	— 5.70	.10	3.1	+ 5.8	271.7864	891.696
				Reverse	+ 182.0	+ .15							
					+ 182.15								
P. B. M. $\frac{2}{1}$^{2}	T. B. M. 32	958	40.691	Direct.....	— 4,406.8	+ 1.55	+ 7.40	— 7.40	1.03	3.3	+ 5.2	267.1984	876.643
				Reverse.....	— 4,403.7	— 1.55							
					— 4,405.25								
P. B. M. $\frac{2}{2}$^{0}; cap on pipe.....	P. B. M. $\frac{2}{1}$^{0}	65	40.756	Direct.....	+ 1,208.2	— .10	+ 7.30	— 7.30	.07	3.3	+ 5.4	268.4066	880.607
				Reverse.....	+ 1,208.0	+ .10							
					+ 1,208.1								
T. B. M. 33	T. B. M. 32	1,805	41.538	Direct.....	+ 851.8	— .05	+ 5.80	— 5.80	.03	3.1	+ 5.8	272.4560	.....
				Reverse.....	+ 851.7	+ .05							
					+ 851.75								

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T. B. M. 34	T. B. M. 33	1,596	43.136	Direct	+ 461.6	+ 1.35	+ 7.15	— 7.15	.90	3.3	+ 5.9	272.9790	895.412
				Reverse	+ 464.3	— 1.35							
					+ 462.95								
T. B. M. 35	T. B. M. 34	1,073	44.209	Direct	— 146.3	— .10	+ 7.05	— 7.05	.07	3.3	+ 5.9	272.7726	.....
				Reverse	— 146.5	+ .10							
					— 146.4								
T. B. M. 36, Anoka, Minn	T. B. M. 35	468	44.677	Direct	+ 759.3	+ .10	+ 7.15	— 7.15	.07	3.3	+ 6.0	273.5321	897.423
				Reverse	+ 759.5	— .10							
					+ 759.4								
T. B. M. 37	T. B. M. 36	842	45.519	Direct	— 7,239.3	— .20	+ 6.95	— 6.95	.13	3.3	+ 5.1	266.2917	.....
				Reverse	— 7,239.7	+ .20							
					— 7,239.5								
P. B. M., Anoka	T. B. M. 37	143	45.662	Direct	— 1,201.0	+ .35	+ 7.30	— 7.30	.23	3.3	+ 4.9	265.0909	869.729
				Reverse	— 1,200.3	— .35							
					— 1,200.65								
3-foot mark of gauge on Anoka bridge.	do	277	45.796	Direct	— 6,675.8	— .35	+ 6.60	— 6.60	.23	3.3	+ 4.3	259.6147	851.762
				Reverse	— 6,676.5	+ .35							
					— 6,676.15								
T. B. M. 38	do	618	46.137	Direct	— 2,634.5	— .60	+ 6.35	— 6.35	.40	3.3	+ 4.8	263.6563	.....
				Reverse	— 2,635.7	+ .60							
					— 2,635.1								
P. B. M. $2\frac{1}{2}$; bolt on tile	T. B. M. 38	42	46.179	Direct	— 747.0	— .15	+ 6.20	— 6.20	.10	3.3	+ 4.7	262.9091	862.57
				Reverse	— 747.3	+ .15							
					— 747.15								
P. B. M. $2\frac{1}{2}$; cap on pipe	T. B. M. 38	42	46.179	Direct	+ 466.2	— .20	+ 6.15	— 6.15	.13	3.3	+ 4.8	264.1223	866.55
				Reverse	+ 465.8	+ .20							
					+ 466.0								
T. B. M. 39	T. B. M. 38	910	47.047	Direct	+ 3,431.3	+ 1.25	+ 7.60	— 7.60	.83	3.4	+ 5.2	267.0892	.....
				Reverse	+ 3,433.8	— 1.25							
					+ 3,432.55								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 40	T. B. M. 39	1,668	48.715	Direct	+ 6,214.7	+ 0.65	+ 8.25	— 8.25	0.43	3.4	+ 5.9	273.3053	
				Reverse	+ 6,216.0	— .65							
					+ 6,215.35								
T. B. M. 41	T. B. M. 40	846	49.561	Direct	— 5,277.9	+ 1.85	+10.10	—10.10	1.23	3.6	+ 5.3	268.0287	
				Reverse	— 5,274.2	— 1.85							
					— 5,276.05								
T. B. M. 42	T. B. M. 41	1,888	51.449	Direct	+ 421.3	+ 2.45	+12.55	—12.55	1.63	4.0	+ 5.4	268.4525	
				Reverse	+ 426.2	— 2.45							
					+ 423.75								
P. B. M. $2\frac{1}{2}$; bolt in tile	T. B. M. 42	19	51.468	Direct	— 960.0	+ .10	+12.65	—12.65	.07	4.0	+ 5.2	267.4924	877.607
				Reverse	— 959.8	— .10							
					— 959.9								
P. B. M. $2\frac{1}{2}$; cap on pipe	T. B. M. 42	19	51.468	Direct	+ 248.0	— .10	+12.45	—12.45	.07	4.0	+ 5.4	268.7004	881.571
				Reverse	+ 247.8	+ .10							
					+ 247.9								
T. B. M. 43	T. B. M. 42	1,869	53.318	Direct	+ 2,444.8	— 2.15	+10.40	—10.40	1.43	4.2	+ 5.6	270.8954	888.772
				Reverse	+ 2,440.5	+ 2.15							
					+ 2,442.65								
T. B. M. 44	T. B. M. 43	1,805	55.123	Direct	+ 3,763.0	— 1.90	+ 8.50	— 8.50	1.27	4.4	+ 6.1	274.6569	
				Reverse	+ 3,759.2	+ 1.90							
					+ 3,761.1								
T. B. M. 45	T. B. M. 44	768	55.891	Direct	— 189.3	— 1.20	+ 7.30	— 7.30	.80	4.5	+ 6.1	274.4665	
				Reverse	— 191.7	+ 1.20							
					— 190.5								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 52	T. B. M. 51	676	63.756	Direct	— 3,586.8	+ 0.75	+ 5.90	— 5.90	0.50	4.7	+ 6.4	277.3286	.....
				Reverse	— 3,585.3	— .75							
					— 3,586.05								
T. B. M. 53	T. B. M. 52	1,368	65.124	Direct	+ 797.5	+ .15	+ 6.05	— 6.05	.10	4.7	+ 6.5	278.1263	.....
				Reverse	+ 797.8	— .15							
					+ 797.65								
P. B. M. 2½⁸; bolt in tile	T. B. M. 53	49	65.173	Direct	— 186.8	.00	+ 6.05	— 6.05	.00	4.7	+ 6.5	277.9395	911.883
				Reverse	— 186.8	.00							
					— 186.8								
P. B. M. 2½⁸; cap on pipe	T. B. M. 53	49	65.173	Direct	+ 1,018.2	.00	+ 6.05	— 6.05	.00	4.7	+ 6.6	279.1446	915.837
				Reverse	+ 1,018.2	.00							
					+ 1,018.2								
T. B. M. 54 (Elk River, Minn.)	T. B. M. 53	865	65.989	Direct	+ 3,463.8	— .90	+ 5.15	— 5.15	.60	4.7	+ 6.9	281.5896	923.859
				Reverse	+ 3,462.0	+ .90							
					+ 3,462.9								
P. B. M. Elk River	T. B. M. 54	1,230	67.219	Direct	— 9,136.8	— .45	+ 4.70	— 4.70	.30	4.8	+ 5.8	272.4512	893.877
				Reverse	— 9,137.7	+ .45							
					— 9,137.25								
T. B. M. 55	P. B. M. Elk River.	1,784	69.003	Direct	+ 3,744.7	— .10	+ 4.60	— 4.60	.07	4.8	+ 6.3	276.1963	.....
				Reverse	+ 3,744.5	+ .10							
					+ 3,744.6								
P. B. M. 2½⁸; bolt in tile	T. B. M. 55	488	69.491	Direct	+ 3,653.8	+ .75	+ 5.35	— 5.35	.50	4.8	+ 6.7	279.8513	918.156
				Reverse	+ 3,655.3	— .75							
					+ 3,654.55								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 63	T. B. M. 62	727	77.883	Direct	+ 1,103.8	— 1.05	— 0.17	+ 0.17	0.70	5.1	+ 7.9	289.5244	.....
				Reverse	+ 1,101.7	+ 1.05							
					+ 1,102.75								
T. B. M. 64	T. B. M. 63	840	78.723	Direct	— 3,072.5	— 1.00	— 1.17	+ 1.17	.67	5.1	+ 7.5	286.4505	.....
				Reverse	— 3,074.5	+ 1.00							
					— 3,073.5								
T. B. M. 65	T. B. M. 64	642	79.365	Direct	+ 3,819.2	+ 1.05	— .12	+ .12	.70	5.2	+ 8.0	290.2713	952.342
				Reverse	+ 3,821.3	— 1.05							
					+ 3,820.25								
P. B. M. $\frac{2}{5}$; bolt in tile	T. B. M. 65	299	79.664	Direct	— 1,774.3	+ .05	— .07	+ .07	.03	5.2	+ 7.8	288.4968	946.520
				Reverse	— 1,774.2	— .05							
					— 1,774.25								
P. B. M. $\frac{2}{5}$; cap on pipe	P. B. M. $\frac{2}{5}$	47	79.711	Direct	+ 1,190.7	+ .05	— .02	+ .02	.03	5.2	+ 7.9	289.6877	950.427
				Reverse	+ 1,190.8	— .05							
					+ 1,190.75								
T. B. M. 66	T. B. M. 65	1,249	80.614	Direct	— 1,318.5	+ 1.50	+ 1.38	— 1.38	1.00	5.3	+ 7.8	288.9541	.....
				Reverse	— 1,315.5	— 1.50							
					— 1,317.0								
T. B. M. 67	T. B. M. 66	896	81.510	Direct	+ 797.3	— .75	+ .63	— .63	.50	5.3	+ 7.9	289.7507	.....
				Reverse	+ 795.8	+ .75							
					+ 796.55								
(A) East Base (Monticello base line); bolt in tile.	T. B. M. 67	89	81.599	Direct	+ 348.3	— .25	+ .38	— .38	.17	5.3	+ 7.9	290.0988	951.776
				Reverse	+ 347.8	+ .25							
					+ 348.05								

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⚠ East Base (Monticello base line); cap on pipe.	T. B. M. 67	89	81.599	Direct	+ 1,562.0	.00	+ .63	— .63	.00	5.3	+ 8.1	291.3129	955.760
				Reverse	+ 1,562.0	.00							
					+ 1,562.0								
T. B. M. 68	T. B. M. 67	982	82.492	Direct	+ 1,515.7	+ 1.05	+ 1.68	— 1.68	.70	5.3	+ 8.1	291.2677	.....
				Reverse	+ 1,517.8	— 1.05							
					+ 1,516.75								
T. B. M. 69	T. B. M. 68	701	83.193	Direct	— 330.8	+ .30	+ 1.98	— 1.98	.20	5.4	+ 8.1	290.9372	.....
				Reverse	— 330.2	— .30							
					— 330.5								
⚠ West Base (Monticello base line); bolt in tile.	T. B. M. 69	59	83.252	Direct	— 953.7	+ .10	+ 2.08	— 2.08	.07	5.4	+ 7.9	289.9834	951.398
				Reverse	— 953.5	— .10							
					— 953.6								
⚠ West Base (Monticello base line); cap on pipe.	T. B. M. 69	59	83.252	Direct	+ 253.5	+ .10	+ 2.08	— 2.08	.07	5.4	+ 8.1	291.1908	955.359
				Reverse	+ 253.7	— .10							
					+ 253.6								
P. B. M. $\frac{1}{2}$; bolt in tile	T. B. M. 69	270	83.463	Direct	— 197.8	+ .15	+ 2.13	— 2.13	.10	5.4	+ 8.0	290.7894	953.878
				Reverse	— 197.5	— .15							
					— 197.65								
P. B. M. $\frac{1}{2}$; cap on pipe	P. B. M. $\frac{1}{2}$	119	83.582	Direct	+ 1,206.8	— .25	+ 1.88	— 1.88	.17	5.4	+ 8.2	291.9462	957.837
				Reverse	+ 1,206.8	+ .25							
					+ 1,206.55								
T. B. M. 70	T. B. M. 69	1,707	84.900	Direct	— 6,414.3	+ .15	+ 2.13	— 2.13	.10	5.4	+ 7.3	284.5222	933.480
				Reverse	— 6,414.0	— .15							
					— 6,414.15								
T. B. M. 71	T. B. M. 70	884	85.784	Direct	+ 5,406.0	+ 1.00	+ 3.13	— 3.13	.67	5.4	+ 7.9	289.9298	951.222
				Reverse	+ 5,408.0	— 1.00							
					+ 5,407.0								
T. B. M. 72	T. B. M. 71	1 485	87.269	Direct	— 1,521.3	— .20	+ 2.93	— 2.93	.13	5.4	+ 7.8	288.4082	.....
				Reverse	— 1,521.7	+ .20							
					— 1,521.5								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
							Direct line.	Reverse line.					
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 73	T. B. M. 72	827	88.096	Direct	+ 7,031.3	— 1.30	+ 1.63	— 1.63	0.87	5.4	+ 8.6	295.4390	
				Reverse	+ 7,028.7	+ 1.30							
					+ 7,030.0								
P. B. M. 2½; bolt in tile	T. B. M. 73	32	88.128	Direct	+ 252.7	+ .05	+ 1.68	— 1.68	.03	5.4	+ 8.6	295.6918	970.126
				Reverse	+ 252.8	— .05							
					+ 252.75								
P. M. B. 2½; cap on pipe	T. B. M. 73	32	88.128	Direct	+ 1,461.3	— .40	+ 1.23	— 1.23	.27	5.4	+ 8.8	296.9001	974.090
				Reverse	+ 1,460.5	+ .40							
					+ 1,460.9								
T. B. M. 74	T. B. M. 73	596	88.692	Direct	+ 62.8	— .30	+ 1.33	— 1.33	.20	5.4	+ 8.6	295.5015	
				Reverse	+ 62.2	+ .30							
					+ 62.5								
T. B. M. 75	T. B. M. 74	1,662	90.354	Direct	— 1,573.3	— .50	+ .83	— .83	.33	5.5	+ 8.4	293.9275	
				Reverse	— 1,574.3	+ .50							
					— 1,573.8								
T. B. M. 76	T. B. M. 75	1,029	91.443	Direct	+ 841.0	— 1.10	— .27	+ .27	.73	5.5	+ 8.5	294.7675	
				Reverse	+ 838.8	+ 1.10							
					+ 839.9								
T. B. M. 77	T. B. M. 76	1,424	92.867	Direct	+ 1,401.7	— 1.35	— 1.62	+ 1.62	.90	5.6	+ 8.7	296.1681	
				Reverse	+ 1,399.0	+ 1.35							
					+ 1,400.35								
T. B. M. 77*a*	T. B. M. 77	593	93.460	Direct	— 5.0	+ .25	— 1.87	+ 1.87	.17	5.6	+ 8.7	296.1633	
				Reverse	— 4.5	— .25							
					— 4.75								

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P. B. M. 1½; bolt in tile	T. B. M. 77a	16	93.476	Direct	— 936.2	— .15	— 1.53	+ 1.52	.10	5.6	+ 3.6	296.2260	968.601		
				Reverse	— 936.5	+ .15									
P. B. M. 1½; cap on pipe	T. B. M. 77a	16	93.476		— 936.35		— 1.17	+ 1.17	.18	5.6	+ 3.7	296.4383	972.575		
				Direct	+ 274.8	+ .20									
				Reverse	+ 275.2	— .20									
T. B. M. 78	T. B. M. 77a	1,795	95.255		+ 275.0		— 2.37	+ 2.37	.67	5.6	+ 3.1	299.5472	.....		
				Direct	+ 3,384.5	— 1.00									
				Reverse	+ 3,382.5	+ 1.00									
T. B. M. 79	T. B. M. 78	1,195	96.450		+ 3,383.5		— 3.57	+ 3.57	.80	5.7	+ 3.1	299.7853	.....		
				Direct	+ 242.2	— 1.20									
				Reverse	+ 239.8	+ 1.20									
T. B. M. 80	T. B. M. 79	1,952	98.402		+ 241.0		— 2.87	+ 2.87	.47	5.7	+ 3.2	300.0028	.....		
				Direct	+ 1,113.3	+ .70									
				Reverse	+ 1,114.7	— .70									
P. B. M. 1½; bolt in tile	T. B. M. 80	33	98.435		+ 1,114.0		— 3.12	+ 3.12	.17	5.7	+ 3.2	300.5088	985.930		
				Direct	— 393.3	— .25									
				Reverse	— 393.8	+ .25									
P. B. M. 1½; cap on pipe	T. B. M. 80	33	98.435		— 393.55		— 2.87	+ 2.87	.00	5.7	+ 3.3	301.7137	989.883		
				Direct	+ 811.3	.00									
				Reverse	+ 811.3	.00									
T. B. M. 81	T. B. M. 80	528	98.960		+ 811.3		— 2.53	+ 2.52	.23	5.7	+ 3.4	302.1512	.....		
				Direct	+ 1,248.3	+ .35									
				Reverse	+ 1,249.0	— .35									
T. B. M. 82	T. B. M. 81	2,057	100.997		+ 1,248.65		— 3.23	+ 3.22	.47	5.7	+ 3.5	303.0174	.....		
				Direct	+ 866.8	— .70									
				Reverse	+ 865.4	+ .70									
T. B. M. 83	T. B. M. 82	918	101.905		+ 866.1		— 2.92	+ 2.92	.20	5.7	+ 3.5	303.3925	.....		
				Direct	+ 374.8	+ .30									
				Reverse	+ 375.4	— .30									
					+ 375.1										

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 84	T. B. M. 83	890	102.795	1st direct	— 1,855.3	+ 2.27	— 0.39	+ 0.39	0.94	5.8	+ 9.3	301.5393	
				1st reverse	— 1,850.5	— 2.53							
				2d direct	— 1,853.3	+ .27							
					— 1,853.03								
P. B. M. 2^{12}; bolt in tile	T. B. M. 84	147	102.942	Direct	+ 424.7	.00	— .39	+ .39	.00	5.8	+ 9.4	301.9640	990.704
				Reverse	+ 424.7	.00							
					+ 424.7								
P. B. M. 2^{12}; cap on pipe	P. B. M. 2^{12}	107	103.049	Direct	+ 1,207.8	.00	— .39	+ .39	.00	5.8	+ 9.5	303.1719	994.667
				Reverse	+ 1,207.8	.00							
					+ 1,207.8								
T. B. M. 85	T. B. M. 84	752	103.547	Direct	+ 899.7	+ 1.50	+ 1.11	— 1.11	1.00	5.9	+ 9.4	302.4406	
				Reverse	+ 902.7	— 1.50							
					+ 901.2								
T. B. M. 86	T. B. M. 85	850	104.397	Direct	+ 1,763.5	+ 1.60	+ 2.71	— 2.71	1.07	6.0	+ 9.6	304.2058	
				Reverse	+ 1,766.7	— 1.60							
					+ 1,765.1								
T. B. M. 87	T. B. M. 86	677	105.074	Direct	+ 342.8	— 1.05	+ 1.66	— 1.66	.70	6.0	+ 9.7	304.5477	999.181
				Reverse	+ 340.7	+ 1.05							
					+ 341.75								
T. B. M. 88	T. B. M. 87	1,546	106.620	Direct	— 3,863.8	+ 1.30	+ 2.96	— 2.96	.87	6.1	+ 9.2	300.6847	
				Reverse	— 3,861.2	— 1.30							
					— 3,862.5								
T. B. M. 89	T. B. M. 88	530	107.150	Direct	+ 5,163.3	— .50	+ 2.46	— 2.46	.33	6.1	+ 9.8	305.8481	
				Reverse	+ 5,162.3	+ .50							
					+ 5,162.8								

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P. B. M. $\frac{2}{14}$; bolt in tile	T. B. M. 89	24	107.174	Direct	− 897.7	.00	+ 2.46	− 2.46	.00	6.1	+ 9.7	304.9503	1,000.502
				Reverse	− 897.7	.00							
					− 897.7								
P. B. M. $\frac{2}{14}$; cap on pipe	T. B. M. 89	24	107.174	Direct	+ 312.8	.00	+ 2.46	− 2.46	.00	6.1	+ 9.9	306.1610	1,004.474
				Reverse	+ 312.8	.00							
					+ 312.8								
T. B. M. 90	T. B. M. 89	1,000	108.150	Direct	+ 521.7	+ 1.00	+ 3.46	− 3.46	.67	6.2	+ 9.9	306.3709	.....
				Reverse	+ 523.7	− 1.00							
					+ 522.7								
T. B. M. 91	T. B. M. 90	1,496	109.646	Direct	− 347.8	.00	+ 3.46	− 3.46	.00	6.2	+ 9.9	306.0231	.....
				Reverse	− 347.8	.00							
					− 347.8								
T. B. M. 95	T. B. M. 91	1,196	110.842	Direct	− 7,172.3	+ .15	+ 3.61	− 3.61	.10	6.2	+ 9.0	298.8500	.....
				Reverse	− 7,172.0	− .15							
					− 7,172.15								
P. B. M. $\frac{2}{15}$ (Clearwater, Minn.); bolt in tile.	T. B. M. 95	32	110.874	Direct	− 1,571.2	− .40	+ 3.21	− 3.21	.27	6.2	+ 8.8	297.2782	975.331
				Reverse	− 1,572.0	+ .40							
					− 1,571.6								
P. B. M. $\frac{2}{15}$; cap on pipe	T. B. M. 95	32	110.874	Direct	− 363.5	.00	+ 3.61	− 3.61	.00	6.2	+ 9.0	298.4866	979.296
				Reverse	− 363.5	.00							
					− 363.5								
T. B. M. 92	T. B. M. 91	1,365	111.011	Direct	+ 2,067.2	− .20	+ 3.26	− 3.26	.13	6.2	+10.1	308.0903	.....
				Reverse	+ 2,066.8	+ .20							
					+ 2,067.0								
T. B. M. 93	T. B. M. 92	1,817	112.828	Direct	+ 206.8	− .40	+ 2.86	− 2.86	.27	6.2	+10.1	308.2967	.....
				Reverse	+ 206.0	+ .40							
					+ 206.4								
T. B. M. 94	T. B. M. 93	1,437	114.265	Direct	+ 3,475.5	− 1.50	+ 1.36	− 1.36	1.00	6.2	+10.6	311.7712	.....
				Reverse	+ 3,472.5	+ 1.40							
					+ 3,474.0								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*ters.*	*Feet.*
P. B. M. $\frac{2}{3}$^{a}; bolt in tile	T. B. M. 94	1,146	115.411	Direct	— 663.0	+ 0.65	+ 2.01	— 2.01	0.43	6.3	+10.5	[illegible] 1087	1,020.707
				Reverse	— 661.7	— .65							
					— 662.35								
P. B. M. $\frac{2}{3}$^{a}; cap on pipe	P. B. M. $\frac{2}{3}$^{a}	111	115.522	Direct	+ 1,206.7	— .10	+ 1.91	— 1.91	.07	6.3	+10.6	312.3154	1,024.666
				Reverse	+ 1,206.5	+ .10							
					+ 1,206.6								
T. B. M. 96	T. B. M. 94	1,438	115.703	Direct	+ 1,854.7	+ 1.30	+ 2.66	— 2.66	.87	6.3	+10.8	313.6274	
				Reverse	+ 1,857.3	— 1.30							
					+ 1,856.0								
T. B. M. 97	T. B. M. 96	1,793	117.496	Direct	+ 890.2	— 1.45	+ 1.21	— 1.21	.97	6.4	+10.9	314.5163	
				Reverse	+ 887.3	+ 1.45							
					+ 888.75								
T. B. M. 98	T. B. M. 97	858	118.354	Direct	+ 452.0	— .65	+ .56	— .56	.43	6.4	+10.9	314.9676	
				Reverse	+ 450.7	+ .65							
					+ 451.35								
P. B. M. $\frac{2}{4}$^{x}; bolt in tile	T. B. M. 98	859	118.713	Direct	— 1,010.5	+ .25	+ .81	— .81	.17	6.4	+10.8	313.9572	1,030.052
				Reverse	— 1,010.0	— .25							
					— 1,010.25								
P. B. M. $\frac{2}{4}$^{x}; cap on pipe	P. B. M. $\frac{2}{4}$^{x}	107	118.820	Direct	+ 1,204.2	— .20	+ .61	— .61	.13	6.4	+11.0	315.1614	1,034.003
				Reverse	+ 1,203.8	+ .20							
					+ 1,204.0								
T. B. M. 99	T. B. M. 98	837	119.191	Direct	— 5,494.9	— .80	— .24	+ .24	.53	6.4	+10.3	309.4713	
				Reverse	— 5,496.5	+ .80							
					— 5,495.7								

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T. B. M. 100	T. B. M. 99	1,055	120.246	Direct	+ 7,129.8	— .50	— .74	+ .74	.33	6.4	+11.1	316.6014	.....	
				Reverse	+ 7,128.8	+ .50								
					+ 7,129.3									
T. B. M. 101	T. B. M. 100	955	121.201	Direct	+ 471.7	— .25	— .99	+ .99	.17	6.4	+11.2	317.0730	.....	
				Reverse	+ 471.2	+ .25								
					+ 471.45									
T. B. M. 102	T. B. M. 101	1,589	122.790	Direct	+ 1,262.7	+ .05	— .94	+ .94	.03	6.4	+11.3	318.3358	.....	
				Reverse	+ 1,262.8	— .05								
					+ 1,262.75									
T. B. M. 103	T. B. M. 102	600	123.390	Direct	+ 649.0	+ .25	— .69	+ .69	.17	6.4	+11.4	318.9852	.....	
				Reverse	+ 649.5	— .25								
					+ 649.25									
P. B. M. 2½ⁿ; bolt in tile	T. B. M. 103	625	124.015	Direct	— 148.7	— .50	— 1.19	+ 1.19	.33	6.4	+11.4	318.8360	1,046.059	
				Reverse	— 149.7	+ .50								
					— 149.2									
P. B. M. 2½ⁿ; cap on pipe	P. B. M. 2½ⁿ	145	124.160	Direct	+ 1,206.2	— .20	— 1.39	+ 1.39	.13	6.4	+11.5	320.0421	1,050.016	
				Reverse	+ 1,205.8	+ .20								
					+ 1,206.0									
T. B. M. 104	T. B. M. 103	1,868	125.258	Direct	+ 2,190.7	+ .40	— .29	+ .29	.27	6.4	+11.7	321.1765	.....	
				Reverse	+ 2,191.5	— .40								
					+ 2,191.1									
T. B. M. 105	T. B. M. 104	2,424	127.682	Direct	— 1,743.7	— .65	— .94	+ .94	.43	6.4	+11.5	319.4320	.....	
				Reverse	— 1,745.0	+ .65								
					— 1,744.35									
T. B. M. 106	T. B. M. 105	612	128.294	Direct	— 1,402.0	+ .15	— .79	+ .79	.10	6.4	+11.3	318.0299	.....	
				Reverse	— 1,401.7	— .15								
					— 1,401.85									
P. B. M. 2½ⁿ; bolt in tile	T. B. M. 106	282	128.576	Direct	— 3,379.7	+ .45	— .34	+ .34	.30	6.5	+10.9	314.6503	1,032.326	
				Reverse	— 3,378.8	— .45								
					— 3,379.25									

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. 2½ (St. Cloud, Minn.); cap on pipe.	P. B. M. 2½	118	128.694	Direct	+ 1,208.7	— 0.20	— 0.54	+ 0.54	0.13	6.5	+11.0	315.8589	1,036.292
				Reverse	+ 1,208.3	+ .20							
					+ 1,208.5								
T. B. M. 107	T. B. M. 106	541	128.835	First direct	+ 3,274.7	— 1.72	— 2.26	+ 2.26	.61	6.5	+11.7	321.3033	.....
				First reverse	+ 3,270.8	+ 2.18							
				Second direct	+ 3,274.2	— 1.22							
				Second reverse	+ 3,272.2	+ .78							
					+ 3,272.98								
P. B. M. St. Cloud	T. B. M. 107	170	129.005	Direct	— 344.2	+ .20	— 2.06	+ 2.06	.13	6.5	+11.7	320.9593	1,053.026
				Reverse	— 343.8	— .20							
					— 344.0								
T. B. M. 108	T. B. M. 107	1,460	130.295	Direct	— 1,310.0	— .90	— 3.16	+ 3.16	.60	6.5	+11.5	319.9922	.....
				Reverse	— 1,311.8	+ .90							
					— 1,310.9								
T. B. M. 109	T. B. M. 108	942	131.237	Direct	— 4,641.0	+ .85	— 2.31	+ 2.31	.57	6.5	+11.0	315.3516	.....
				Reverse	— 4,639.3	— .85							
					— 4,640.15								
T. B. M. 110	T. B. M. 109	1,304	132.541	First direct	— 2,993.7	— 3.78	— 5.33	+ 5.33	1.68	6.7	+10.6	312.3537	1,024.792
				First reverse	— 3,004.8	+ 7.32							
				Second direct	— 2,995.2	— 2.28							
				Second reverse	— 2,996.2	— 1.28							
					— 2,997.48								
T. B. M. 111	T. B. M. 110	1,289	133.830	Direct	+ 3,440.3	— .65	— 5.98	+ 5.98	.43	6.8	+11.0	315.7938	.....
				Reverse	+ 3,439.0	+ .65							
					+ 3,439.65								

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P. B. M. $2\frac{1}{2}$; bolt in tile	T. B. M. 111	229	134.069	Direct	− 4,278.5	− .40	− 6.38	+ 6.38	.27	6.8	+10.5	311.5143	1,022.038
				Reverse	− 4,279.3	+ .40							
					− 4,278.9		− 6.78	+ 6.78	.27	6.8	+10.7	312.7219	1,026.000
P. B. M. $2\frac{1}{2}$; cap on pipe	P. B. M. $2\frac{1}{2}$	98	184.157	Direct	+ 1,207.8	− .40							
				Reverse	+ 1,207.0	+ .40							
					+ 1,207.4		− 5.93	+ 5.93	.03	6.8	+10.7	313.0747	1,027.157
T. B. M. 112	T. B. M. 111	501	134.331	Direct	− 2,718.8	+ .05							
				Reverse	− 2,718.7	− .05							
					− 2,718.75								
T. B. M. 113	T. B. M. 112	1,811	136.142	Direct	+ 5,120.7	+ .50	− 5.43	+ 5.43	.33	6.8	+11.3	318.1965	.....
				Reverse	+ 5,121.7	− .50							
					+ 5,121.2								
T. B. M. 114	T. B. M. 113	1,701	137.843	Direct	− 2,158.2	+ .25	− 5.18	+ 5.18	.17	6.8	+11.1	316.0383	.....
				Reverse	− 2,157.7	− .25							
					− 2,157.95								
T. B. M. 115	T. B. M. 114	754	138.597	Direct	+ 2,007.5	− .65	− 5.83	+ 5.83	.43	6.8	+11.3	318.0454	.....
				Reverse	+ 2,006.2	+ .65							
					+ 2,006.85								
P. B. M. $2\frac{1}{2}$; bolt in tile	T. B. M. 115	94	138.691	Direct	+ 838.0	− .10	− 5.93	+ 5.93	.07	6.8	+11.4	318.8834	1,046.215
				Reverse	+ 837.8	+ .10							
					+ 837.9								
P. B. M. $2\frac{1}{2}$; cap on pipe	P. B. M. $2\frac{1}{2}$	42	138.733	Direct	+ 1,210.2	+ .25	− 5.68	+ 5.68	.17	6.8	+11.5	320.0939	1,050.186
				Reverse	+ 1,210.7	− .25							
					+ 1,210.45								
T. B. M. 116	T. B. M. 115	1,296	139.893	Direct	+ 2,818.7	− .20	− 6.03	+ 6.03	.13	6.8	+11.6	320.8642	.....
				Reverse	+ 2,818.3	+ .20							
					+ 2,818.5								
T. B. M. 117	T. B. M. 116	1,093	140.986	Direct	− 3,195.8	+ .40	− 5.63	+ 5.63	.27	6.8	+11.3	317.6685	.....
				Reverse	− 3,195.0	− .40							
					− 3,195.4								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V.		r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
							Direct line.	Reverse line.					
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 118	T. B. M. 117	944	141.930	Direct	+ 1,592.3	— 1.50	— 7.13	+ 7.13	1.00	6.9	+11.4	319.2594	
				Reverse	+ 1,589.3	+ 1.50							
					+ 1,590.8								
P. B. M. 2½²; bolt in tile	T. B. M. 118	20	141.950	Direct	— 987.2	+ .10	— 7.03	+ 7.03	.07	6.9	+11.3	318.2722	1,044.209
				Reverse	— 987.0	— .10							
					— 987.1								
P. B. M. 2½²; cap on pipe	T. B. M. 118	20	141.950	Direct	+ 220.3	+ .10	— 7.03	+ 7.03	.07	6.9	+11.5	319.4799	1,048.172
				Reverse	+ 220.5	— .10							
					+ 220.4								
T. B. M. 119	T. B. M. 118	901	142.831	Direct	+ 1,323.0	— .35	— 7.48	+ 7.48	.23	6.9	+11.6	320.5822	
				Reverse	+ 1,322.3	+ .35							
					+ 1,322.65								
T. B. M. 120	T. B. M. 119	1,264	144.095	Direct	— 4,291.5	— .40	— 7.88	+ 7.88	.27	6.9	+11.1	316.2899	
				Reverse	— 4,292.3	+ .40							
					— 4,291.9								
T. B. M. 121	T. B. M. 120	792	144.887	Direct	+ 6,360.8	+ 1.60	— 6.28	+ 6.28	1.07	7.0	+11.9	322.6531	
				Reverse	+ 6,364.0	— 1.60							
					+ 6,362.4								
T. B. M. 122	T. B. M. 121	1,432	146.319	Direct	+ 679.8	— .25	— 6.53	+ 6.53	.17	7.0	+11.9	323.3326	
				Reverse	+ 679.3	+ .25							
					+ 679.55								
P. B. M. 2½²; bolt in tile	T. B. M. 123	1,127	147.446	Direct	— 2,905.2	+ 1.10	— 5.43	+ 5.43	.73	7.0	+11.6	320.4282	1,051.283
				Reverse	— 2,903.0	— 1.10							
					— 2,904.1								

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P. B. M. $\frac{2}{3}$; cap on pipe	P. B. M. $\frac{2}{3}$	152	147.598	Direct	+ 1,210.7	.00	— 5.43	+ 5.43	.00	7.0	+11.7	321.6390	1,055.266
				Reverse	+ 1,210.7	.00							
					+ 1,210.7								
T. B. M. 123	T. B. M. 122	2,151	148.470	Direct	+ 4,515.5	— .60	— 7.13	+ 7.13	.40	7.0	+12.5	327.8481	.....
				Reverse	+ 4,514.3	+ .60							
					+ 4,514.9								
T. B. M. 124	T. B. M. 123	737	149.207	Direct	+ 654.5	+ .50	— 6.63	+ 6.63	.33	7.0	+12.6	328.5032	.....
				Reverse	+ 655.5	— .50							
					+ 655.0								
⚓ Back Base (Rice base line)	T. B. M. 124	376	.....	Direct	— 457.5	— 1.15	— 7.78	+ 7.78	.77	7.0	+12.5	328.0445	1,076.271
				Reverse	— 459.8	+ 1.15							
					— 458.65								
⚓ Back base, cap on pipe	⚓ Back base	251	.....	Direct	+ 1,213.3	— .65	— 8.43	+ 8.43	.43	7.0	+12.6	329.2572	1,080.250
				Reverse	+ 1,212.0	+ .65							
					+ 1,212.65								
T. B. M. 125	T. B. M. 124	1,364	150.571	Direct	— 841.7	+ .85	— 5.78	+ 5.78	.57	7.0	+12.5	327.6628	.....
				Reverse	— 840.0	— .85							
					— 840.85								
⚓ River base (Rice base line) bolt in tile.	T. B. M. 125	17	150.588	Direct	— 713.7	.00	— 5.78	+ 5.78	.00	7.0	+12.4	326.9484	1,072.675
				Reverse	— 713.7	.00							
					— 713.7								
⚓ River base, cap on pipe	T. B. M. 125	17	150.588	Direct	+ 499.0	.00	— 5.78	+ 5.78	.00	7.0	+12.5	328.1613	1,076.654
				Reverse	+ 499.0	.00							
					+ 499.0								
T. B. M. 126	T. B. M. 125	1,041	151.612	Direct	+ 1,205.7	+ .25	— 5.53	+ 5.53	.17	7.0	+12.6	328.8683	.....
				Reverse	+ 1,206.2	— .25							
					+ 1,205.95								
P. B. M. $\frac{2}{4}$, bolt in tile	T. B. M. 126	22	151.634	Direct	— 1,310.0	— .15	— 5.68	+ 5.68	.10	7.0	+12.4	327.5580	1,074.675
				Reverse	— 1,310.3	+ .15							
					— 1,310.15								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. $2\frac{4}{4}$, cap on pipe	T. B. M. 126	22	151.634	Direct	— 98.5	+ 0.15	— 5.38	+ 5.38	0.10	7.0	+12.6	328.7700	1,078.651
				Reverse	— 98.2	— .15							
					— 98.35								
T. B. M. 127	T. B. M. 126	489	152.101	Direct	+ 450.3	— .65	— 6.18	+ 6.18	.43	7.0	+12.7	329.3181	.....
				Reverse	+ 449.0	+ .65							
					+ 449.65								
T. B. M. 128	T. B. M. 127	1,977	154.078	Direct	— 478.3	+ .25	— 5.93	+ 5.93	.17	7.0	+12.6	328.8399	.....
				Reverse	— 477.8	— .25							
					— 478.05								
T. B. M. 129 (Russell Ferry)	T. B. M. 128	1,970	156.048	Direct	— 1,966.0	+ .10	— 5.83	+ 5.83	.07	7.0	+12.4	326.8738	1,072.430
				Reverse	— 1,965.8	— .10							
					— 1,965.9								
T. B. M. 130	T. B. M. 129	771	156.819	Direct	+ 696.7	+ 1.40	— 4.43	+ 4.43	.03	7.1	+12.4	327.5719	.....
				Reverse	+ 699.5	— 1.40							
					+ 698.1								
P. B. M. $2\frac{8}{8}$, bolt in tile	T. B. M. 130	32	156.851	Direct	— 435.3	.00	— 4.43	+ 4.43	.00	7.1	+12.4	327.1366	1,073.292
				Reverse	— 435.3	.00							
					— 435.3								
P. B. M. $2\frac{8}{2}$, cap on pipe	T. B. M. 130	32	156.851	Direct	+ 775.3	— .15	— 4.58	+ 4.58	.10	7.1	+12.5	328.3471	1,077.264
				Reverse	+ 775.0	+ .15							
					+ 775.15								
T. B. M. 131	T. B. M. 130	834	157.653	Direct	+ 421.2	+ .30	— 4.13	+ 4.13	.20	7.1	+12.5	327.9935	.....
				Reverse	+ 421.8	— .30							
					+ 421.5								

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T. B. M. [illegible]	T. B. M. 131	961	158.614	Direct	+ 1,880.5	— .15	— 4.28	+ 4.28	.10	7.1	+12.7	329.8801	
				Reverse	+ 1,880.2	+ .15							
					+ 1,880.35								
T. B. M. 133	T. B. M. 132	1,744	160.358	Direct	+ 1,629.7	— 1.35	— 5.63	+ 5.63	.90	7.1	+12.9	331.5086	1,087.686
				Reverse	+ 1,627.0	+ 1.35							
					+ 1,628.35								
T. B. M. 134	T. B. M. 133	1,901	162.259	Direct	— 3,983.5	+ .35	— 5.28	+ 5.28	.23	7.1	+12.4	327.5250	
				Reverse	— 3,982.8	— .35							
					— 3,983.15								
T. B. M. 135	T. B. M. 134	228	162.487	Direct	— 1,653.0	+ .25	— 5.03	+ 5.03	.17	7.1	+12.2	325.8720	
				Reverse	— 1,652.5	— .25							
					— 1,652.75								
P. B. M. 2[c], bolt in tile	T. B. M. 135	9	162.496	Direct	— 1,169.5	.00	— 5.03	+ 5.03	.00	7.1	+12.1	324.7024	1,065.306
				Reverse	— 1,169.5	.00							
					— 1,169.5								
P. B. M. 2[c], cap on pipe	T. B. M. 135	9	162.496	Direct	+ 38.5	.00	— 5.03	+ 5.03	.00	7.1	+12.2	325.9105	1,069.270
				Reverse	+ 38.5	.00							
					+ 38.5								
T. B. M. 136	T. B M. 135	1,162	163.649	Direct	+ 3,559.8	— .15	— 5.18	+ 5.18	.10	7.1	+12.7	329.4321	
				Reverse	+ 3,559.5	+ .15							
					+ 3,559.65								
T. B. M. 137	T. B. M. 136	1,455	165.104	Direct	+ 3,989.3	+ .35	— 4.83	+ 4.83	.23	7.1	+13.1	333.4222	
				Reverse	+ 3,990.0	— .35							
					+ 3,989.65								
T. B. M. 138	T. B. M. 137	2,230	167.334	Direct	+ 473.3	+ .75	— 4.08	+ 4.08	.50	7.2	+13.2	333.8964	
				Reverse	+ 474.8	— .75							
					+ 474.05								
P. B. M. 2[f], bolt in tile	T. B. M. 138	409	167.743	Direct	— 2,935.5	— 1.25	— 5.33	+ 5.33	.83	7.2	+12.9	330.9593	1,065.334
				Reverse	— 2,938.0	+ 1.25							
					— 2,936.75								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. 2$\frac{1}{2}$^{z} (North Prairie, Minn.), cap on pipe.	P. B. M. 2$\frac{1}{2}$^{z}	106	167.849	Direct.....	+ 1,212.3	+ 0.20	— 5.13	+ 5.13	0.13	7.2	+13.0	332.1719	1,089.813
				Reverse.....	+ 1,212.7	— .20							
					+ 1,212.5								
T. B. M. 139	T. B. M. 138	1,654	168.988	Direct.....	+ 1,924.3	+ 1.10	— 2.98	+ 2.98	.73	7.2	+13.4	335.8220	.....
				Reverse.....	+ 1,926.5	— 1.10							
					+ 1,925.4								
T. B. M. 140	T. B. M. 139	1,885	170.873	Direct.....	+ 1,251.8	— 2.40	— 5.38	+ 5.38	1.60	7.4	+13.6	337.0716	.....
				Reverse.....	+ 1,247.0	+ 2.40							
					+ 1,249.4								
P. B. M. 2$\frac{1}{2}$^{s}, bolt in tile.....	T. B. M. 140	673	171.546	Direct.....	+ 587.2	— .75	— 6.13	+ 6.13	.50	7.4	+13.7	337.6581	1,107.812
				Reverse.....	+ 585.7	+ .75							
					+ 586.45								
P. B. M. 2$\frac{1}{2}$^{s}, cap on pipe.....	P. B. M. 2$\frac{1}{2}$^{s}	86	171.632	Direct.....	+ 1,211.5	+ .10	— 6.03	+ 6.03	.07	7.4	+13.8	338.8698	1,111.788
				Reverse.....	+ 1,211.7	— .10							
					+ 1,211.6								
T. B. M. 141	T. B. M. 140	588	171.461	Direct.....	+ 24.3	+ .20	— 5.18	+ 5.18	.18	7.4	+13.6	337.0960	.....
				Reverse.....	+ 24.7	— .20							
					+ 24.5								
T. B. M. 142	T. B. M. 141	1,983	173.444	Direct.....	+ 1,555.2	+ .65	— 4.53	+ 4.53	.43	7.4	+13.8	338.6521	.....
				Reverse.....	+ 1,556.5	— .65							
					+ 1,555.85								
T. B. M. 143	T. B. M. 142	1,607	175.051	Direct.....	+ 2,329.2	+ .25	— 4.28	+ 4.28	.17	7.4	+14.1	340.9819	.....
				Reverse.....	+ 2,329.7	— .25							
					+ 2,329.45								

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P. B. M. $\frac{2}{3}^{29}$, bolt in tile	T. B. M. 143	724	175.775	Direct	− 1,892.7	− 1.00	− 5.28	+ 5.28	.67	7.4	+13.8	339.0878	1,112.508
				Reverse	− 1,894.7	+ 1.00							
					− 1,893.7								
P. B. M. $\frac{2}{3}^{28}$, cap on pipe	P. B. M. $\frac{2}{3}^{28}$	80	175.855	Direct	+ 1,199.7	+ .25	− 5.03	+ 5.03	.17	7.4	+13.9	340.2879	1,116.404
				Reverse	+ 1,200.2	− .25							
					+ 1,199.95								
T. B. M. 144	T. B. M. 143	1,689	176.740	Direct	− 677.7	+ .50	− 3.78	+ 3.78	.33	7.4	+14.0	340.3046	.....
				Reverse	− 676.7	− .50							
					− 677.2								
T. B. M. 145	T. B. M. 144	1,309	178.049	Direct	+ 64.8	+ .10	− 3.68	+ 3.68	.07	7.4	+14.0	340.3694	.....
				Reverse	+ 65.0	− .10							
					+ 64.9								
T. B. M. 146	T. B. M. 145	1,562	179.611	Direct	+ 1,802.3	.00	− 3.68	+ 3.68	.00	7.4	+14.2	342.1720	.....
				Reverse	+ 1,802.3	.00							
					+ 1,802.3								
T. B. M. 147	T. B. M. 146	699	180.310	Direct	− 500.0	+ .15	− 3.53	+ 3.53	.10	7.4	+14.1	341.6720	.....
				Reverse	− 499.7	− .15							
					− 499.85								
P. B. M. $\frac{2}{3}^{29}$; bolt in tile	T. B. M. 147	344	180.654	Direct	+ 730.0	+ 1.00	− 2.53	+ 2.53	.67	7.4	+14.2	342.4031	1,123.380
				Reverse	+ 732.0	− 1.00							
					+ 731.0								
P. B. M. $\frac{2}{3}^{29}$; cap on pipe	P. B. M. $\frac{2}{3}^{29}$	103	180.757	Direct	+ 1,203.2	− .45	− 2.98	+ 2.98	.30	7.4	+14.4	343.6060	1,127.326
				Reverse	+ 1,202.3	+ .45							
					+ 1,202.75								
T. B. M. 148	T. B. M. 147	1,469	181.779	Direct	+ 1,972.7	− .35	− 3.88	+ 3.88	.23	7.4	+14.4	343.6446	.....
				Reverse	+ 1,972.0	+ .35							
					+ 1,972.35								
T. B. M. 149	T. B. M. 148	1,296	183.075	Direct	+ 934.7	+ .05	− 3.83	+ 3.83	.08	7.4	+14.5	344.5795	.....
				Reverse	+ 934.8	− .05							
					+ 934.75								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 150	T. B. M. 149	2,387	185.462	Direct	+ 2,812.7	— 0.25	— 4.08	+ 4.08	0.17	7.4	+14.8	347.3922	
				Reverse	+ 2,812.2	+ .25							
					+ 2,812.45								
P. B. M. $\frac{2}{3}g^1$; bolt in tile	T. B. M. 150	271	185.733	Direct	— 2,131.7	+ .50	— 3.58	+ 3.58	.33	7.4	+14.6	345.2608	1,132.756
				Reverse	— 2,130.7	— .50							
					— 2,131.2								
P. B. M. $\frac{2}{3}g^1$; cap on pipe	P. B. M. $\frac{2}{3}g^1$	82	185.815	Direct	+ 1,210.3	— .05	— 3.63	+ 3.63	.08	7.4	+14.7	346.4712	1,136.727
				Reverse	+ 1,210.2	+ .05							
					+ 1,210.25								
T. B. M. 151	T. B. M. 150	864	186.326	Direct	— 680.3	.00	— 4.08	+ 4.08	.00	7.4	+14.7	346.7119	
				Reverse	— 680.3	.00							
					— 680.3								
T. B. M. 152 (Little Falls, Minn.)	T. B. M. 151	722	187.048	Direct	— 1,014.0	— 1.40	— 5.48	+ 5.48	.93	7.5	+14.6	345.6964	1,134.185
				Reverse	— 1,016.8	+ 1.40							
					— 1,015.4								
T. B. M. 153	T. B. M. 152	1,158	188.201	Direct	+ 1,020 0	— .65	— 6 13	+ 6.13	.43	7.5	+14.7	346.7158	
				Reverse	+ 1,018.7	+ .65							
					+ 1,019.35								
T. B. M. 154	T. B. M. 153	1,318	189.519	Direct	+ 970.5	— .65	— 6.78	+ 6.78	.43	7.5	+14.9	347.6859	
				Reverse	+ 969.2	+ .65							
					+ 969 85								
T. B. M. 155	T. B. M. 154	854	190.373	Direct	— 63.0	— .35	— 7.13	+ 7.13	.23	7.5	+14.9	347.6225	
				Reverse	— 63.7	+ .35							
					— 63.35								

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P. B. M. $\frac{2}{2}$; bolt in tile	T. B. M. 155	96	190.469	Direct	− 516.2	− .30	− 7.43	+ 7.43	.20	7.5	+14.8	347.1058	1,138.809
				Reverse	− 516.8	+ .30							
					− 516.5								
P. B. M. $\frac{2}{2}$; cap on pipe	T. B. M. 155	96	190.469	Direct	+ 680.5	− .40	− 7.53	+ 7.53	.27	7.5	+14.9	348.3020	1,142.735
				Reverse	+ 679.7	+ .40							
					+ 680.1								
T. B. M. 156	T. B. M. 155	1,066	191.439	Direct	+ 1,193.7	+ .30	− 6.83	+ 6.83	.20	7.5	+15.0	348.8166	.....
				Reverse	+ 1,194.3	− .30							
					+ 1,194.0								
T. B. M. 157	T. B. M. 156	1,686	193.125	Direct	− 153.0	+ 1.35	− 5.48	+ 5.48	.90	7.5	+15.0	348.6650	.....
				Reverse	− 150.3	− 1.35							
					− 151.65								
T. B. M. 158	T. B. M. 157	673	193.798	Direct	+ 1,480.2	+ .55	− 4.93	+ 4.93	.37	7.6	+15.2	350.1459	.....
				Reverse	+ 1,481.3	− .55							
					+ 1,480.75								
T. B. M. 159	T. B. M. 158	1,228	195.026	Direct	+ 1,041.5	.00	− 4.93	+ 4.93	.00	7.6	+15.3	351.1875	.....
				Reverse	+ 1,041.5	.00							
					+ 1,041.5								
P. B. M. $\frac{3}{3}$; bolt in tile	T. B. M. 159	295	195.321	Direct	− 1,105.0	+ .10	− 4.83	+ 4.83	.07	7.6	+15.1	350.0824	1,148.575
				Reverse	− 1,104.8	− .10							
					− 1,104.9								
P. B. M. $\frac{3}{3}$; cap on pipe	P. B. M. $\frac{2}{2}$	157	195.478	Direct	+ 1,211.7	+ .40	− 4.43	+4.43	.27	7.6	+15.3	351.2947	1,152.552
				Reverse	+ 1,212.5	− .40							
					+ 1,212.1								
T. B. M. 160	T. B. M. 159	1,922	196.948	Direct	+ 1,011.5	− .75	− 5.68	+ 5.68	.50	7.6	+15.4	352.1984	.....
				Reverse	+ 1,010.0	+ .75							
					+ 1,010.75								
T. B. M. 161	T. B. M. 160	696	197.644	First direct	+ 18.2	− 2.50	− 7.93	+ 7.93	1.36	7.7	+15.4	352.2140	.....
				First reverse	+ 9.7	+ 6.00							
				Second direct	+ 17.7	− 2.00							
				Second reverse	+ 17.2	− 1.50							
					+ 15.7								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	ΣV. Direct line.	ΣV. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 162	T. B. M. 161	715	198.359	Direct	+ 1,021.2	— 0.25	— 8.18	+ 8.18	0.17	7.7	+15.5	353.2351	
				Reverse	+ 1,020.7	+ .25							
					+ 1,020.95								
T. B. M. 163	T. B. M. 162	468	198.827	Direct	+ 134.0	— .65	— 8.83	+ 8.83	.43	7.7	+15.5	353.3685	
				Reverse	+ 132.7	+ .65							
					+ 133.35								
P. B. M. $\frac{2}{4}$; bolt in tile	T. B. M. 163	87	198.864	Direct	— 967.0	— .15	— 8.68	+ 8.68	.10	7.7	+15.4	352.4012	1,156.182
				Reverse	— 967.3	+ .15							
					— 967.15								
P. B. M. $\frac{2}{4}$; cap on pipe	T. B. M. 163	87	198.864	Direct	+ 243.0	.00	— 8.83	+ 8.83	.00	7.7	+15.6	353.6116	1,160.154
				Reverse	+ 243.0	.00							
					+ 243.0								
T. B. M. 164	T. B. M. 163	1,163	199.990	Direct	+ 1,082.3	+ .35	— 8.48	+ 8.48	.23	7.7	+15.7	354.4513	
				Reverse	+ 1,083.0	— .35							
					+ 1,082.65								
T. B. M. 165	T. B. M. 164	1,650	201.640	Direct	+ 796.2	— .20	— 8.68	+ 8.68	.13	7.7	+15.8	355.2474	
				Reverse	+ 795.8	+ .20							
					+ 796.0								
T. B. M. 166	T. B. M. 165	780	202.420	Direct	+ 547.8	+ .10	— 8.58	+ 8.58	.07	7.7	+15.8	355.7953	
				Reverse	+ 548.0	— .10							
					+ 547.9								
T. B. M. 167	T. B. M. 166	817	203.237	Direct	+ 3.5	— .65	— 9.23	+ 9.23	.43	7.7	+15.8	355.7982	
				Reverse	+ 2.2	+ .65							
					+ 2.85								

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P. B. M. $^{sg^2}$; bolt in tile	T. B. M. 167	770	204.007	Direct	— 1,346.7	.00	— 9.23	+ 9.23	.00	7.7	+15.7	354.4513	1,162.908
				Reverse	— 1,346.7	.00							
					— 1,346.7								
P. B. $^{sg^2}$; cap on pipe	P. B. M. $^{sg^2}$	165	204.172	Direct	+ 1,214.8	— .30	— 9.53	+ 9.53	.20	7.7	+15.8	355.6660	1,166.894
				Reverse	+ 1,214.2	+ .30							
					+ 1,214.5								
T. B. M. 168	T. B. M. 167	753	203.990	Direct	+ 523.8	— .50	— 9.73	+ 9.73	.33	7.7	+15.9	356.3215	.....
				Reverse	+ 522.8	+ .50							
					+ 523.3								
T. B. M. 169	T. B. M. 168	1,391	205.381	Direct	+ 1,536.8	— .65	—10.38	+10.38	.43	7.7	+16.1	357.8579	.....
				Reverse	+ 1,535.5	+ .65							
					+ 1,536.15								
T. B. M. 170	T. B. M. 169	1,666	207.047	Direct	+ 2,537.0	— .75	—11.13	+11.13	.50	7.8	+16.4	360.3944	.....
				Reverse	+ 2,535.5	+ .75							
					+ 2,536.25								
T. B. M. 173	T. B. M. 170	1,251	208.298	Direct	— 2,820.2	+ 1.25	— 9.88	+ 9.88	.83	7.8	+16.0	357.5751	.....
				Reverse	— 2,817.7	— 1.25							
					— 2,818.95								
P. B. M. $^{sg^2}$; bolt in tile	T. B. M. 173	36	208.334	Direct	— 593.0	+ .10	— 9.78	+ 9.78	.07	7.8	+16.0	356.9822	1,171.212
				Reverse	— 592.8	— .10							
					— 592.9								
P. B. M. $^{sg^2}$; cap on pipe	T. B. M. 173	36	208.334	Direct	+ 624.2	— .20	—10.08	+10.08	.13	7.8	+16.1	358.1992	1,175.205
				Reverse	+ 623.8	+ .20							
					+ 624.0								
T. B. M. 171	T. B. M. 170	786	207.833	Direct	+ 1,712.2	— .45	—11.58	+11.58	.30	7.8	+16.6	362.1064	.....
				Reverse	+ 1,711.3	+ .45							
					+ 1,711.75								
T. B. M. 172	T. B. M. 171	2,002	209.835	Direct	+ 1,645.7	— .35	—11.93	+11.93	.23	7.8	+16.8	363.7520	.....
				Reverse	+ 1,645.0	+ .35							
					+ 1,645.35								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 174	T. B. M. 172	666	210.501	First direct	— 1,610.4	+ 3.23	— 9.56	+ 9.56	1.12	7.8	+16.6	362.1446	
				First reverse	— 1,604.8	— 2.37							
				Second direct	— 1,606.3	— .87							
					— 1,607.17								
T. B. M. 175	T. B. M. 174	1,193	211.694	Direct	— 813.8	+ 1.50	— 8.06	+ 8.06	1.00	7.9	+16.5	361.3322	
				Reverse	— 810.8	— 1.50							
					— 812.3								
P. B. M. $\frac{8}{27}$; bolt in tile	T. B. M. 175	27	211.721	Direct	— 1,361.5	+ .15	— 7.91	+ 7.91	.10	7.9	+16.3	359.9706	1,181.017
				Reverse	— 1,361.2	— .15							
					— 1,361.35								
P. B. M. $\frac{8}{27}$; cap on pipe	T. B. M. 175	27	211.721	Direct	— 147.3	+ .30	— 7.76	+ 7.76	.20	7.9	+16.5	361.1852	1,185.001
				Reverse	— 146.7	— .30							
					— 147.0								
T. B. M. 176	T. B. M. 175	1,769	213.463	Direct	— 1,806.8	+ 1.30	— 6.76	+ 6.76	.87	8.0	+16.3	359.5265	
				Reverse	— 1,804.2	— 1.30							
					— 1,805.5								
T. B. M. 177	T. B. M. 176	2,348	215.811	Direct	+ 4,563.8	+ .95	— 5.81	+ 5.81	.63	8.0	+16.3	364.0917	
				Reverse	+ 4,565.7	— .95							
					+ 4,564.75								
T. B. M. 178	T. B. M. 177	540	216.351	Direct	— 474.0	+ .10	— 5.71	+ 5.71	.07	8.0	+16.3	363.6178	
				Reverse	— 473.8	— .10							
					— 473.9								
P. B. M. $\frac{8}{28}$; bolt in tile	T. B. M. 178	579	216.930	Direct	— 3,833.5	+ .15	— 5.56	+ 5.56	.10	8.0	+16.3	359.7840	1,180.404
				Reverse	— 3,833.2	— .15							
					— 3,833.35								

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P. B. M. $^{2}g^{2}$; cap on pipe	P. B. M. $^{2}g^{2}$	19	216.949	Direct	+ 1,210.8	— .30	— 5.86	+ 5.86	.20	8.0	+16.5	360.9947	1,184.376
				Reverse	+ 1,210.2	+ .30							
					+ 1,210.5								
T. B. M. 179	T. B. M. 178	1,465	217.816	Direct	+ 1,183.7	+ 1.00	— 4.71	+ 4.71	.67	8.0	+16.9	364.8026	
				Reverse	+ 1,185.7	— 1.00							
					+ 1,184.7								
T. B. M. 180	T. B. M. 179	2,109	220.015	Direct	+ 2,707.5	— .25	— 4.96	+ 4.96	.17	8.0	+17.2	367.5102	
				Reverse	+ 2,707.0	+ .25							
					+ 2,707.25								
T. B. M. 181	T. B. M. 180	1,186	221.201	Direct	— 142.3	+ .05	— 4.91	+ 4.91	.03	8.0	+17.2	367.3679	
				Reverse	— 142.2	— .05							
					— 142.25								
P. B. M. $^{2}g^{2}$; bolt in tile	T. B. M. 181	16	221.217	Direct	— 382.2	.00	— 4.91	+ 4.91	.....	8.0	+17.2	366.9857	1,204.032
				Reverse	— 383.2	.00							
					— 382.2								
P. B. M. $^{2}g^{2}$; cap on pipe	T. B. M. 181	16	221.217	Direct	+ 828.0	.00	— 4.91	+ 4.91	.....	8.0	+17.3	368.1960	1,208.003
				Reverse	+ 828.0	.00							
					+ 828.0								
T. B. M. 182	T. B. M. 181	980	222.181	Direct	— 8,758.2	— 1.25	— 6.16	+ 6.16	.83	8.1	+16.2	358.6075	
				Reverse	— 8,760.7	+ 1.25							
					— 8,759.45								
T. B. M. 183	T. B. M. 182	1,398	223.579	Direct	+ 2,168.5	+ .25	— 5.91	+ 5.91	.17	8.1	+16.4	360.7764	
				Reverse	+ 2,169.0	— .25							
					+ 2,168.75								
T. B. M. 184	T. B. M. 183	1,413	224.992	Direct	+ 304.8	— 2.05	— 7.96	+ 7.96	1.37	8.2	+16.5	361.0793	
				Reverse	+ 300.7	+ 2.05							
					+ 302.75								
T. B. M. 185	T. B. M. 184	708	225.700	Direct	— 80.0	— .40	— 8.36	+ 8.36	.27	8.2	+16.5	360.9989	
				Reverse	— 80.8	+ .40							
					— 80.4								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. M. B. 2½°; bolt in tile.....	T. B. M. 185	449	226.149	Direct.....	+ 7,004.0	+ 0.15	— 8.21	+ 8.21	0.10	8.2	+17.3	368.9038	1,207.372
				Reverse.....	+ 7,004.3	— .15							
					+ 7,004.15								
P. B. M. 2½°; cap on pipe.....	P. B. M. 2½°	193	226.342	Direct.....	+ 1,210.2	+ .40	— 7.81	+ 7.81	.27	8.2	+17.4	369.2145	1,211.344
				Reverse.....	+ 1,211.0	— .40							
					+ 1,210.6								
T. B. M. 186	T. B. M. 185	1,927	227.627	Direct.....	+ 8,903.7	— .10	— 8.46	+ 8.46	.07	8.2	+17.5	369.9035	.....
				Reverse.....	+ 8,903.5	+ .10							
					+ 8,903.6								
T. B. M. 187	T. B. M. 186	2,154	229.781	Direct.....	+ 237.3	— 1.90	—10.36	+10.36	1.27	8.3	+17.6	370.1390	.....
				Reverse.....	+ 233.5	+ 1.90							
					+ 235.4								
T. B. M. 188	T. B. M. 187	1,342	231.123	Direct.....	+ 436.7	— 1.25	—11.61	+11.61	.83	8.3	+17.6	370.5744	.....
				Reverse.....	+ 434.2	+ 1.25							
					+ 435.45								
P. B. M. 2½¹; bolt in tile.....	T. B. M. 188	807	231.980	Direct.....	— 5,578.3	— .85	—12.46	+12.46	.57	8.3	+16.9	364.9046	1,197.500
				Reverse.....	— 5,580.0	+ .85							
					— 5,579.15								
P. B. M. 2½¹; cap on pipe.....	P. B. M. 2½¹	185	232.115	Direct.....	+ 1,209.7	+ .15	—12.31	+12.31	.10	8.3	+17.1	366.2046	1,201.470
				Reverse.....	+ 1,210.0	— .15							
					+ 1,209.85								
T. B. M. 189	T. B. M. 188	747	231.870	Direct.....	+ 1,927.0	+ .50	—11.11	+11.11	.33	8.3	+17.8	372.5021	.....
				Reverse.....	+ 1,928.0	— .50							
					+ 1,927.5								

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T. B. M. 190	T. B. M. 189	1,048	232.918	Direct	— 446.7	— .40	—11.51	+11.51	.27	8.3	+17.8	372.0550	
				Reverse	— 447.5	+ .40							
					— 447.1								
T. B. M. 191	T. B. M. 190	821	233.739	Direct	+ 1,068.2	+ 1.00	—10.51	+10.51	.67	8.4	+17.9	373.1243	
				Reverse	+ 1,070.2	— 1.00							
					+ 1,069.2								
T. B. M. 192	T. B. M. 191	1,875	235.614	Direct	+ 868.7	+ .55	— 9.96	+ 9.96	.37	8.4	+18.0	373.9937	
				Reverse	+ 869.8	— .55							
					+ 869.25								
T. B. M. 193	T. B. M. 192	424	236.038	Direct	— 3,432.2	— .65	—10.61	+10.61	.43	8.4	+17.6	370.5604	
				Reverse	— 3,433.5	+ .65							
					— 3,432.85								
P. B. M. 2½²; bolt in tile	T. B. M. 193	799	236.837	Direct	— 1,045.4	+ .60	—10.01	+10.01	.40	8.4	+17.5	369.5155	1,212.832
				Reverse	— 1,044.2	— .60							
					— 1,044.8								
P. B. M. 2½²; cap on pipe	P. B. M. 2½²	41	236.878	Direct	+ 1,208.2	+ .25	— 9.76	+ 9.76	.17	8.4	+17.6	370.7241	1,216.297
				Reverse	+ 1,208.7	— .25							
					+ 1,208.45								
T. B. M. 194	T. B. M. 193	1,518	237.556	Direct	— 7,116.2	— .10	—10.51	+10.51	.07	8.4	+16.8	363.4435	
				Reverse	— 7,116.0	+ .10							
					— 7,116.1								
T. B. M. 195	T. B. M. 194	2,460	240.016	Direct	+20,118.8	— 1.50	—12.81	+12.81	1.00	8.4	+19.2	383.5632	1,258.421
				Reverse	+20,115.8	+ 1.50							
					+20,117.3								
T. B. M. 196	T. B. M. 195	2,009	242.025	Direct	— 4,923.2	— 1.80	—13.81	+13.81	1.20	8.5	+18.6	378.6376	1,242.260
				Reverse	— 4,926.8	+ 1.80							
					— 4,925.0								
T. B. M. 197	T. B. M. 196	1,542	243.567	Direct	— 4,382.0	+ 1.40	—12.41	+12.41	.93	8.6	+18.0	374.2564	
				Reverse	— 4,379.2	— 1.40							
					— 4,380.6								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct. line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 199	T. B. M. 197	825	244.392	Direct	+ 2,963.7	+ 0.75	—11.66	+11.66	0.50	8.6	+18.4	377.2213	
				Reverse	+ 2,965.2	— .75							
					+ 2,964.45								
P. B. M. 3½³ (Brainerd, Minn.); bolt in tile.	T. B. M. 199	31	244.423	Direct	— 424.2	+ .10	—11.[illegible]	+11.56	.07	8.6	+18.4	376.7972	1,236.222
				Reverse	— 424.0	— .10							
					— 424.1								
P. B. M. 3½²; cap on pipe	T. B. M. 199	31	244.423	Direct	+ 785.0	+ .15	—11.51	+11.51	.10	8.6	+18.5	378.0065	1,240.190
				Reverse	+ 785.3	— .15							
					+ 785.15								
T. B. M. 202	P. B. M. 3½³; cap on pipe.	1,480	245.903	Direct	— 2,214.7	.00	—11.51	+11.51	.00	8.6	+18.2	375.7915	
				Reverse	— 2,214.7	.00							
					— 2,214.7								
P. B. M. Sanitarium; bolt in tile.	T. B. M. 202	97	246.000	Direct	— 1,236.8	— .10	—11.61	+11.61	.07	8.6	+18.1	374.5545	1,228.864
				Reverse	— 1,237.0	+ .10							
					— 1,236.9								
P. B. M. Sanitarium; cap on pipe.	T. B. M. 202	97	246.000	Direct	+ 5.8	+ .20	—11.31	+11.31	.13	8.6	+18.2	375.7975	1,232.942
				Reverse	+ 6.2	— .20							
					+ 6.0								
T. B. M. 198	T. B. M. 197	1,801	245.368	Direct	— 885.7	+ .45	—11.96	+11.96	.30	8.6	+17.9	373.3711	
				Reverse	— 884.8	— .45							
					— 885.25								
T. B. M. 200	T. B. M. 198	1,005	246.373	Direct	+ 2,986.0	+ .75	—11.21	+11.21	.50	8.6	+18.3	376.3582	
				Reverse	+ 2,987.5	— .75							
					+ 2,986.75								

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⚓South Base (Brainerd); bolt in tile.	T. B. M. 200	39	246.412	Direct	— 529.8	+ .15	—11.06	+11.06	.10	8.6	+18.2	375.8285	1,233.044
				Reverse	— 529.5	— .15							
					— 529.65								
⚓South Base (Brainerd); cap on pipe.	T. B. M. 200	39	246.412	Direct	+ 682.7	— .45	—11.06	+11.06	.30	8.6	+18.4	377.0406	1,237.021
				Reverse	+ 681.8	+ .45							
					+ 682.25								
T. B. M. 201	T. B. M. 200	1,614	247.987	Direct	— 2,527.1	— .60	—11.81	+11.81	.40	8.6	+18.0	373.8302	.....
				Reverse	— 2,528.3	+ .60							
					— 2,527.7								
⚓North Base (Brainerd); bolt in tile.	T. B. M. 201	15	248.002	Direct	— 701.5	+ .10	—11.71	+11.71	.07	8.6	+17.9	373.1287	1,224.187
				Reverse	— 701.3	— .10							
					— 701.4								
⚓North Base (Brainerd); cap on pipe.	T. B. M. 201	15	248.002	Direct	+ 512.2	.00	—11.81	+11.81	.00	8.6	+18.1	374.3425	1,228.169
				Reverse	+ 512.2	.00							
					+ 512.2								
P. B. M. $2\frac{1}{4}$; bolt in tile	T. B. M. 201	207	248.194	Direct	— 197.2	.00	—11.81	+11.81	.00	8.6	+18.0	373.6330	1,225.841
				Reverse	— 197.2	.00							
					— 197.2								
P. B. M. $2\frac{1}{4}$; cap on pipe	T. B. M. 201	207	248.194	Direct	+ 1,011.5	— .65	—12.46	+12.46	.43	8.6	+18.1	374.3412	1,229.805
				Reverse	+ 1,010.2	+ .65							
					+ 1,010.85								
T. B. M. 203	T. B. M. 201	704	248.691	Direct	— 6,949.1	— .50	—12.31	+12.31	.33	8.6	+17.2	366.8798	.....
				Reverse	— 6,950.1	+ .50							
					— 6,949.6								
T. B. M. 204	T. B. M. 203	1,145	249.836	Direct	+ 7,665.0	— .65	—13.96	+12.96	.43	8.6	+18.1	374.5451	
				Reverse	+ 7,663.7	+ .65							
					+ 7,664.35								
T. B. M. 205	T. B. M. 204	1,307	251.143	First direct	+ 1,584.7	+ 3.80	—10.56	+10.56	1.01	8.7	+18.3	376.1333	.....
				First reverse	+ 1,591.5	— 3.50							
				Second direct	+ 1,586.5	+ 1.50							
				Second reverse	+ 1,589.3	— 1.30							
					+ 1,588.0								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	ΣV. Direct line.	ΣV. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 206	T. B. M. 205	654	251.797	Direct	— 3,772.8	— 0.20	—10.76	+10.76	0.13	8.7	+17.8	372.3598	
				Reverse	— 3,773.2	+ .20							
					— 3,773.0								
T. B. M. 207	T. B. M. 206	575	252.372	Direct	— 8,145.0	— 3.00	—11.46	+11.46	1.06	8.7	+16.8	364.2108	
				Reverse	— 8,148.7	+ .70							
				Second direct	— 8,150.3	+ 2.30							
					— 8,148.0								
T. B. M. 208	T. B. M. 207	287	252.659	Direct	+ 76.3	+ .65	—10.81	+10.81	.43	8.8	+16.9	364.2878	
				Reverse	+ 77.6	— .65							
					+ 76.95								
T. B. M. 209	T. B. M. 208	1,402	254.061	Direct	+ 433.0	— .10	—10.91	+10.91	.07	8.8	+16.9	364.7207	
				Reverse	+ 432.8	+ .10							
					+ 432.9								
P. B. M. $3\frac{1}{2}^{s}$; bolt in tile	T. B. M. 209	129	254.190	Direct	+12,006.2	+ .30	—10.61	+10.61	.20	8.8	+18.3	376.7286	1,235.997
				Reverse	+12,006.8	— .30							
					+12,006.5								
P. B. M. $3\frac{1}{2}^{s}$; cap on pipe	P. B. M. $3\frac{1}{2}^{s}$	23	254.213	Direct	+ 1,213.0	+ .10	—10.51	+10.51	.07	8.8	+18.5	377.9419	1,239.978
				Reverse	+ 1,213.2	— .10							
					+ 1,213.1								
T. B. M. 210	P. B. M. $3\frac{1}{2}^{s}$; cap on pipe.	10	254.223	Direct	— 1,380.8	— .35	—10.86	+10.86	.23	8.8	+18.3	376.5606	1,235.446
				Reverse	— 1,381.5	+ .35							
					— 1,381.15								
T. B. M. 211	P. B. M. $3\frac{1}{2}^{s}$; cap on pipe.	8	254.221	Direct	— 331.2	— .15	—10.66	+10.66	.10	8.8	+18.4	377.6105	1,238.891
				Reverse	— 331.5	+ .15							
					— 331.35								

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T. B. M. 260	T. B. M. 205	979	252.122	Direct	+ 5,728.5	+ .90	— 9.66	+ 9.66	.60	8.7	+19.0	381.8634	.....
				Reverse	+ 5,730.3	— .90							
					+ 5,729.4								
T. B. M. 261	T. B. M. 260	1,379	253.501	Direct	+ 1,102.5	— .60	—10.26	+10.26	.40	8.7	+19.1	382.9654	.....
				Reverse	+ 1,101.3	+ .60							
					+ 1,101.9								
T. B. M. 262	T. B. M. 261	768	254.269	Direct	— 8,861.0	— .75	—11.01	+11.01	.50	8.7	+18.0	374.1025	.....
				Reverse	— 8,862.5	+ .75							
					— 8,861.75								
T. B. M. 263	T. B. M. 262	793	255.062	Direct	+ 30.0	— 1.10	—12.11	+12.11	.73	8.8	+18.0	374.1314	.....
				Reverse	+ 27.8	+ 1.10							
					+ 28.9								
T. B. M. 264	T. B. M. 263	701	255.763	Direct	+ 3,704.3	— 1.55	—13.66	+13.66	1.03	8.8	+18.5	377.8347	1,239.626
				Reverse	+ 3,701.2	+ 1.55							
					+ 3,702.75								
T. B. M. 265	T. B. M. 264	775	256.538	Direct	+ 331.3	— .40	—14.06	+14.06	.27	8.8	+18.5	378.1656	.....
				Reverse	+ 330.5	+ .40							
					+ 330.9								
T. B. M. 266	T. B. M. 265	1,585	258.123	Direct	+ 474.3	— .30	—14.36	+14.36	.20	8.8	+18.6	374.6397	.....
				Reverse	+ 473.7	+ .30							
					+ 474.0								
T. B. M. 267	T. B. M. 266	1,443	259.566	Direct	+ 114.0	— .90	—15.26	+15.26	.60	8.8	+18.6	378.7528	.....
				Reverse	+ 112.2	+ .90							
					+ 113.1								
T. B. M. 268	T. B. M. 267	1,035	260.601	Direct	— 1,366.7	— .50	—15.76	+15.76	.38	8.8	+18.4	377.3854	.....
				Reverse	— 1,367.7	+ .50							
					— 1,367.2								
T. B. M. 269	T. B. M. 268	1,518	262.119	Direct	— 741.5	+ 1.10	—14.66	+14.66	.73	8.9	+18.3	376.6449	.....
				Reverse	— 739.3	— 1.10							
					— 740.4								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
							Direct line.	Reverse line.					
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 270	T. B. M. 269	1,470	263.589	Direct	+ 1,847.0	+ 1.15	—13.51	+13.51	0.77	8.9	+18.6	378.4933	
				Reverse	+ 1,849.3	— 1.15							
					+ 1,848.15								
T. B. M. 271	T. B. M. 270	1,710	265.299	Direct	— 1,474.0	— .35	—13.86	+13.86	.23	8.9	+18.4	377.0188	
				Reverse	— 1,474.7	+ .35							
					— 1,474.35								
T. B. M. 272	T. B. M. 271	1,677	266.976	Direct	—10,813.8	+ 1.50	—12.36	+12.36	1.00	9.0	+17.1	366.2052	
				Reverse	—10,810.8	— 1.50							
					—10,812.3								
T. B. M. 212	T. B. M. 272	461	267.437	Direct	+11,932.8	— .15	—12.51	+12.51	.10	9.0	+18.5	378.1392	1,240.625
				Reverse	+11,932.5	+ .15							
					+11,932.65								
P. B. M. 2½; bolt in tile	T. B. M. 212	71	267.508	Direct	— 3,490.8	— .35	—12.86	+12.86	.28	9.0	+18.1	374.6477	1,229.170
				Reverse	— 3,491.5	+ .35							
					— 3,491.15								
P. B. M. 2½; cap on pipe	T. B. M. 212	71	267.508	Direct	— 2,285.2	— .25	—12.76	+12.76	.17	9.0	+18.2	375.8535	1,233.126
				Reverse	— 2,285.7	+ .25							
					— 2,285.45								
T. B. M. 212A	P. B. M. 2½; cap on pipe.	12	267.520	Direct	— 2.0	.00	—12.76	+12.76	.00	9.0	+18.2	375.8515	1,233.120
				Reverse	— 2.0	.00							
					— 2.0								
T. B. M. 213	T. B. M. 212	1,039	268.476	Direct	— 6,452.5	+ .25	—12.26	+12.26	.17	9.0	+17.7	371.6862	
				Reverse	— 6,452.0	— .25							
					— 6,452.25								

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T. B. M. 214	T. B. M. 213	817	269.298	Direct	— 6,731.7	+ .75	—11.51	+11.51	.50	9.0	+16.9	364.9544	
				Reverse	— 6,730.2	— .75							
					— 6,730.95								
T. B. M. 215	T. B. M. 214	1,302	270.595	Direct	— 358.0	+ 1.60	— 9.91	+ 9.91	1.07	9.0	+16.9	364.5980	
				Reverse	— 354.8	— 1.60							
					— 356.4								
T. B. M. 216	T. B. M. 215	906	271.501	Direct	+ 166.2	— .70	—10.61	+10.61	.47	9.1	+16.9	364.7635	
				Reverse	+ 164.8	+ .70							
					+ 165.5								
T. B. M. 217	T. B. M. 216	744	272.245	Direct	+ 243.5	— .15	—10.76	+10.76	.10	9.1	+16.9	365.0069	
				Reverse	+ 243.2	+ .15							
					+ 243.35								
P. B. M. 2½²; bolt in tile	T. B. M. 217	152	272.397	Direct	+19,052.5	— .10	—10.86	+10.86	.07	9.1	+19.2	384.0616	1,260.056
				Reverse	+19,052.3	+ .10							
					+19,052.4								
P. B. M. 2½²; cap on pipe	P. B. M. 2½²	29	272.426	Direct	+ 1,206.8	— .05	—10.91	+10.91	.03	9.1	+19.4	385.2685	1,264.016
				Reverse	+ 1,206.7	+ .05							
					+ 1,206.75								
T. B. M. 218	T. B. M. 217	1,207	273.452	Direct	+ 81.5	+ .50	—10.26	+10.26	.33	9.1	+16.9	365.0889	
				Reverse	+ 82.5	— .50							
					+ 82.0								
T. B. M. 219	T. B. M. 218	727	274.179	Direct	+ 7,907.2	— .20	—10.46	+10.46	.18	9.1	+17.9	372.9969	
				Reverse	+ 7,906.8	+ .20							
					+ 7,907.0								
T. B. M. 220	T. B. M. 219	1,154	275.333	Direct	— 3,003.2	— .40	—10.86	+10.86	.27	9.1	+17.5	369.9929	
				Reverse	— 3,004.0	+ .40							
					— 3,003.6								
T. B. M. 221	T. B. M. 220	2,003	277.336	Direct	— 5,142.0	— 1.10	—11.96	+11.96	.73	9.1	+16.9	364.8492	
				Reverse	— 5,144.2	+ 1.10							
					— 5,143.1								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. $\frac{21}{2}$; bolt in tile	T. B. M. 221	225	277.561	Direct	+ 687.0	— 0.40	—12.36	+12.36	0.27	9.1	+17.0	365.5359	1,199.276
				Reverse	+ 686.2	+ .40							
					+ 686.6								
P. B. M. $\frac{21}{2}$; cap on pipe	P. B. M. $\frac{21}{2}$	56	277.617	Direct	+ 1,209.0	— .40	—12.76	+12.76	.27	9.1	+17.1	366.7446	1,203.241
				Reverse	+ 1,208.2	+ .40							
					+ 1,208.6								
T. B. M. 223	T. B. M. 221	646	277.982	Direct	+ 535.8	.00	—11.96	+11.96	.00	9.1	+17.0	365.3851	.....
				Reverse	+ 535.8	.00							
					+ 535.8								
T. B. M. 223	T. B. M. 222	666	278.648	Direct	+ 7.2	+ 1.00	—10.96	+10.96	.67	9.1	+17.0	365.3933	1,198.808
				Reverse	+ 9.2	— 1.00							
					+ 8.2								
T. B. M. 224	T. B. M. 223	648	279.296	Direct	— 568.5	— 1.15	—12.11	+12.11	.77	9.2	+16.9	364.8235	.....
				Reverse	— 570.8	+ 1.15							
					— 569.65								
T. B. M. 225	T. B. M. 224	691	279.987	Direct	+ 845.5	— 1.00	—13.11	+13.11	.67	9.2	+17.0	365.6681	1,199.709
				Reverse	+ 843.5	+ 1.00							
					+ 844.5								
T. B. M. 226	T. B. M. 255	1,097	281.084	Direct	+ 2,011.5	+ .25	—12.86	+12.86	.17	9.2	+17.3	367.6802	.....
				Reverse	+ 2,012.0	— .25							
					+ 2,011.75								
T. B. M. 227	T. B. M. 226	1,101	282.185	Direct	— 149.8	— .75	—13.61	+13.61	.50	9.2	+17.2	367.5295	.....
				Reverse	— 151.3	+ .75							
					— 150.55								

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P. B. M. 2^{1}_{2}; bolt in tile	T. B. M. 227	692	282.877	Direct	+ 3,110.3	+ .60	−13.01	+13.01	.40	9.2	+17.6	370.6408	1,216.024
				Reverse	+ 3,111.5	− .60							
					+ 3,110.9								
P. B. M. 2^{1}_{2}; cap on pipe	P. B. M. 2^{1}_{2}	83	282.960	Direct	+ 1,209.8	− .40	−13.41	+13.41	.27	9.2	+17.8	371.8504	1,219.992
				Reverse	+ 1,209.0	+ .40							
					+ 1,209.4								
T. B. M. 228	T. B. M. 227	225	292.410	First direct	+14,066.2	+ 1.63	−12.14	+12.14	.61	9.2	+18.9	381.5991	.....
				Reverse	+14,069.3	− 1.47							
				Second direct	+14,068.0	− .17							
					+14,067.83								
T. B. M. 229	T. B. M. 228	1,203	283.613	Direct	−10,071.0	+ .45	−11.69	+11.69	.80	9.2	+17.7	371.5273	.....
				Reverse	−10,070.1	− .45							
					−10,070.55								
T. B. M. 230	T. B. M. 229	1,050	284.663	Direct	− 3,998.0	− .15	−11.84	+11.84	.10	9.2	+17.2	367.5287	.....
				Reverse	− 3,998.3	+ .15							
					− 3,998.15								
T. B. M. 231	T. B. M. 230	812	285.475	Direct	+ 2,376.3	+ .70	−11.14	+11.14	.47	9.2	+17.5	369.9060	.....
				Reverse	+ 2,377.7	− .70							
					+ 2,377.0								
P. B. M. 2^{1}_{2}; bolt in tile	T. B. M. 231	78	285.553	Direct	− 1,362.7	− .05	−11.19	+11.19	.03	9.2	+17.4	368.5431	1,209.142
				Reverse	− 1,362.8	+ .05							
					− 1,362.75								
P. B. M. 2^{1}_{2}; cap on pipe	T. B. M. 231	78	285.553	Direct	− 159.0	.00	− 11.14	+ 11.14	.00	9.2	+17.5	369.7470	1,213.092
				Reverse	− 159.0	.00							
					− 159.0								
T. B. M. 232	T. B. M. 231	1,211	286.686	Direct	+ 5,603.7	+ .05	− 11.09	+ 11.09	.08	9.2	+18.2	375.5104	.....
				Reverse	+ 5,603.8	− .05							
					+ 5,603.75								
T. B. M. 233	T. B. M. 232	816	287.502	Direct	+ 660.0	+ 1.15	− 9.94	+ 9.94	.77	9.3	+18.3	376.1717	.....
				Reverse	+ 662.3	− 1.15							
					+ 661.15								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 234	T. B. M. 233	1,856	288.858	Direct	+ 396.8	— 0.75	— 10.69	+ 10.69	0.50	9.3	+18.3	376.5692	
				Reverse	+ 396.8	+ .75							
					+ 397.55								
T. B. M. 235	T. B. M. 234	878	289.736	Direct	+ 300.5	— .60	— 11.29	+ 11.29	.40	9.3	+18.4	376.8692	
				Reverse	+ 299.3	+ .60							
					+ 299.9								
P. B. M. 2$^{1}_{2}$; bolt in tile	T. B. M. 235	330	290.066	Direct	— 6,539.7	.00	— 11.29	+ 11.29	.00	9.3	+17.6	370.3287	1,215.000
				Reverse	— 6,539.7	.00							
					— 6,539.7								
P. B. M. 2$^{1}_{2}$; cap on pipe	P. B. M. 2$^{1}_{2}$	110	290.176	Direct	+ 1,210.7	+ .05	— 11.24	+ 11.24	.03	9.3	+17.7	371.5396	1,218.973
				Reverse	+ 1,210.8	— .05							
					+ 1,210.75								
T. B. M. 236	T. B. M. 235	1,298	291.034	Direct	— 453.8	+ .30	— 10.99	+ 10.99	.20	9.3	+18.3	376.4156	
				Reverse	— 453.2	— .30							
					— 453.5								
T. B. M. 237	T. B. M. 236	823	292.857	Direct	— 1,073.2	— .50	— 11.49	+ 11.49	.33	9.3	+18.2	375.3418	
				Reverse	— 1,074.2	+ .50							
					— 1,073.7								
T. B. M. 238	T. B. M. 237	1,114	292.971	Direct	— 1,437.2	+ .70	—10.79	+10.79	.47	9.3	+18.0	373.9051	
				Reverse	— 1,435.8	— .70							
					— 1,436.5								
T. B. M. 239	T. B. M. 238	1,356	294.327	Direct	+ 2,898.3	+ 1.10	— 9.69	+ 9.69	.73	9.3	+18.4	376.8049	
				Reverse	+ 2,900.5	— 1.10							
					+ 2,899.4								

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T. B. M. 240	T. B. M. 239	662	294.989	Direct	— 313.3	— .45	—10.14	+10.14	.30	9.3	+18.3	375.9911	
				Reverse	— 314.2	+ .45							
					— 313.75								
T. B. M. 241	T. B. M. 240	542	295.537	First direct	— 1,055.7	— 2.10	—12.84	+12.84	.84	9.4	+18.1	374.9331	
				Reverse	— 1,060.0	+ 2.20							
				Second direct	— 1,057.7	— .10							
					— 1,057.8								
T. B. M. 242	T. B. M. 241	397	295.934	Direct	— 119.7	— .15	—12.49	+12.49	.10	9.4	+18.1	374.8132	
				Reverse	— 120.0	+ .15							
					— 119.85								
P. B. M. 242; bolt in tile	T. B. M. 242	9	295.943	Direct	— 986.0	— .25	—12.74	+12.74	.17	9.4	+18.0	373.8269	1,226.477
				Reverse	— 986.5	+ .25							
					— 986.25								
P. B. M. 242; cap on pipe	T. B. M. 242	9	295.943	Direct	+ 225.3	— .25	—12.74	+12.74	.17	9.4	+18.1	375.0333	1,230.452
				Reverse	+ 224.8	+ .25							
					+ 225.05								
T. B. M. 243	T. B. M. 242	1,121	297.055	Direct	+ 1,490.3	— .05	—12.54	+12.54	.09	9.4	+18.3	376.3037	
				Reverse	+ 1,490.2	+ .05							
					+ 1,490.25								
T. B. M. 244	T. B. M. 243	728	297.778	Direct	— 1,305.7	— 1.05	—12.89	+12.89	.70	9.4	+18.1	374.9967	
				Reverse	— 1,307.8	+ 1.05							
					— 1,306.75								
T. B. M. 245	T. B. M. 244	1,235	298.188	Direct	+ 49.2	+ .95	—12.64	+12.64	.69	9.4	+18.1	375.0469	
				Reverse	+ 51.1	— .95							
					+ 50.15								
T. B. M. 246	T. B. M. 245	1,235	299.423	Direct	+ 1,213.3	— .05	—12.69	+12.69	.69	9.4	+18.3	376.2608	
				Reverse	+ 1,213.2	+ .05							
					+ 1,213.25								
T. B. M. 247	T. B. M. 246	703	301.121	Direct	— 87.3	+ .40	—12.29	+12.29	.27	9.4	+18.3	376.1734	
				Reverse	— 86.5	— .40							
					— 86.9								

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. $\frac{a}{14}$; bolt in tile	T. B. M. 247	427	301.618	Direct	— 713.0	— 0.60	—12.89	+12.89	0.40	9.4	+18.2	375.4597	1,231.834
				Reverse	— 714.2	+ .60							
					— 713.6								
P. B. M. $\frac{a}{14}$; cap on pipe	P. B. M. $\frac{a}{14}$	18	301.636	Direct	+ 1,210.0	+ .10	—12.79	+12.79	.07	9.4	+18.3	376.6699	1,235.805
				Reverse	+ 1,210.2	— .10							
					+ 1,210.1								
T. B. M. 248	T. B. M. 247	1,855	303.046	Direct	+ 136.2	+ .40	—11.89	+11.89	.27	9.4	+18.3	376.3100	.....
				Reverse	+ 137.0	— .40							
					+ 136.6								
T. B. M. 249	T. B. M. 248	1,375	304.421	Direct	— 1,564.0	— .90	—12.79	+12.79	.60	9.5	+18.1	374.7449	.....
				Reverse	— 1,565.8	+ .90							
					— 1,564.9								
T. B. M. 250	T. B. M. 249	1,545	305.966	First direct	— 3,259.0	+ 3.77	— 9.75	+ 9.75	1.35	9.6	+17.7	371.4893	.....
				Reverse	— 3,252.2	— 3.03							
				Second direct	— 3,254.5	— .73							
					— 3,255.23								
T. B. M. 252	T. B. M. 250	2,000	307.966	Direct	+ 2,652.2	+ 1.25	— 8.50	+ 8.50	.83	9.6	+18.0	374.1430	.....
				Reverse	+ 2,654.7	— 1.25							
					+ 2,653.45								
P. B. M. $\frac{a}{12}$; bolt in tile	T. B. M. 252	228	308.194	Direct	— 519.5	+ .10	— 8.40	+ 8.40	.07	9.6	+18.0	373.6236	1,225.810
				Reverse	— 519.3	— .10							
					— 519.4								
P. B. M. $\frac{a}{12}$; cap on pipe	T. B. M. 252	228	308.194	Direct	+ 690.0	— .25	— 8.75	+ 8.75	.17	9.6	+18.1	374.8329	1,229.778
				Reverse	+ 689.5	+ .25							
					+ 689.75								

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T. B. M. 251														
	T. B. M. 250	1,661	307.627	Direct	— 205.7	+ .95	— 8.80	+ 8.80	.68	9.6	+17.7	371.2845	1,218.196	
				Reverse	— 203.8	+ .95								
T. B. M. 253														
	T. B. M. 251	1,035	308.662	Direct	— 204.75		— 8.80	+ 8.80	.00	9.6	+17.7	371.4923	.....	
				Reverse	+ 207.8	.00								
					+ 207.8	.00								
P. B. M. 4½; bolt in tile														
	T. B. M. 253	880	309.043	Direct	— 275.2	+ .20	— 8.60	+ 8.60	.13	9.6	+17.7	371.2178	1,217.915	
				Reverse	— 274.8	+ .20								
P. B. M. 4½; cap on pipe														
	P. B. M. 4½	85	309.097	Direct	— 275.0	.00	— 8.60	+ 8.60	.00	9.6	+17.8	372.4222	1,221.663	
				Reverse	+ 1,210.8	.00								
					+ 1,210.8									
T. B. M. 254														
	T. B. M. 253	1,750	310.412	Direct	— 217.5	— .85	— 8.65	+ 8.65	.57	9.6	+17.7	371.2740	.....	
				Reverse	— 219.2	+ .85								
T. B. M. 255														
	T. B. M. 254	737	311.149	Direct	— 218.35	— .85	—10.50	+10.50	.57	9.6	+17.9	372.6318	.....	
				Reverse	+ 1,358.5	+ .85								
					+ 1,356.8									
P. B. M. 4½; bolt in tile														
	T. B. M. 255	945	311.497	Direct	+ 1,357.65	— .10	—10.60	+10.60	.07	9.6	+17.7	371.3552	1,218.368	
				Reverse	— 1,276.3	— .10								
					— 1,276.5									
P. B. M. 4½; cap on pipe														
	P. B. M. 4½	60	311.557	Direct	— 1,276.4	— .30	—10.90	+10.90	.20	9.6	+17.8	372.5613	1,222.825	
				Reverse	+ 1,206.3	— .30								
					+ 1,205.7									
T. B. M. 256														
	T. B. M. 255	1,039	312.188	Direct	+ 1,206.0	— 1.10	—11.60	+11.60	.73	9.6	+17.9	372.7144	.....	
				Reverse	+ 83.7	+ 1.10								
					+ 81.5									
T. B. M. 257														
	T. B. M. 256	1,730	313.918	Direct	+ 82.6	— .50	—12.10	+12.10	.83	9.6	+17.8	372.5596	.....	
				Reverse	— 134.2	+ .50								
					— 155.2									
					— 154.7									

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TABLE NO. 5.—*Results of precise leveling, St. Paul, Minn., to Aitkin, Minn., 1898*—Continued.

Bench mark.	Determined from.	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r ±.	R ±.	Rod correction.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 258	T. B. M. 257	1,298	315.216	Direct	+ 2,062.0	— 0.35	—12.45	+12.45	0.23	9.6	+18.1	374.6216	
				Reverse	+ 2,061.3	+ .35							
					+ 2,061.65								
T. B. M. 259	T. B. M. 258	442	315.658	Direct	— 310.0	— .65	—13.10	+13.10	.43	9.7	+18.1	374.3109	1,228.065
				Reverse	— 311.3	+ .65							
					— 310.65								
P. B. M., Court-house (Aitkin)	T. B. M. 259	77	315.735	Direct	+ 2,457.1	— .15	—13.25	+13.25	.10	9.7	+18.3	376.7681	1,236.127
				Reverse	+ 2,456.8	+ .15							
					+ 2,456.95								
Base of rail on N. P. R. R. at Aitkin station	T. B. M. 259	334	315.992	Direct	+ 644.7						+18.1	374.9556	1,230.180
P. B. M. $\frac{2}{12}$; bolt in tile	T. B. M. 258	818	316.034	Direct	— 3,323.0	+ .85	—12.10	+12.10	.23	9.6	+17.7	371.2985	1,218.182
				Reverse	— 3,322.3	— .85							
					— 3,322.65								
P. B. M. $\frac{2}{12}$; cap on pipe	P. B. M. $\frac{2}{12}$	41	316.075	Direct	+ 1,211.0	— .15	—12.25	+12.25	.10	9.6	+17.8	372.5095	1,222.155
				Reverse	+ 1,210.7	+ .15							
					+ 1,210.85								
T. B. M. 273	P. B. M. $\frac{2}{12}$; cap on pipe.	1,497	317.572	Direct	— 202.3	— .70	—12.95	+12.95	.47	9.7	+17.8	372.3065	1,221.451
				Reverse	— 203.7	+ .70							
					— 203.0								
(S) Lower Base (Aitkin, Minn.)	T. B. M. 273	21	317.593	Direct	— 941.0	— .10	—13.05	+13.05	.07	9.7	+17.7	371.2659	1,218.409
				Reverse	— 941.2	+ .10							
					— 941.1								
(S) Lower Base; cap on pipe	T. B. M. 273	21	317.593	Direct	+ 272.5	— .25	—12.20	+12.20	.17	9.7	+17.8	372.5787	1,222.362
				Reverse	+ 272.0	+ .25							
					+ 272.25								

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APPENDIX 1 E.

INSTRUCTIONS FOR PRECISE LEVEL WORK.

OFFICE OF THE SECRETARY, MISSISSIPPI RIVER COMMISSION,
St. Louis, Mo., February 28, 1899.

The following general instructions, amended to date, are issued for the guidance of assistant engineers and others under the orders of this office.

MASON M. PATRICK,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

INSTRUCTIONS FOR PRECISE LEVELS.

Instruments.—The instruments used on this work are the Kern levels and rods, similar to those used in the precise levels of Swizerland, and were made by J. Kern, of Aarau. The instrument, with tripod, weighs 22 pounds. It has three steel leveling screws, with enlarged spherical ends at bottom, which are held to the tripod head by clamps fitting over the spherical enlargements. The wye adjustment is by means of a thumbscrew of very fine thread, so that the last final centering of the bubble is made with this screw. The bubble tube is fixed in a striding metal case covered with wood, with brass ends fitting on the collars of the telescope. The bubble case has a glass cover and a mirror that may be raised to the angle of 45° and so reflect the bubble image to the eye of the observer at the eyepiece. The telescope clamps also hold the bubble case in position. This is removed, however, when the instrument is carried. The telescope gives an inverted image. The telescope has three horizontal wires, all of which are read and the mean taken as the reading of that sight. This also gives a stadia measurement of the distance.

The rods are 3 meters long, made of two pine boards with a T-shaped cross section, provided with an iron spur at bottom with a flat end, and a watch level by which to hold it vertical. They are graduated to centimeters, and are read by estimation to millimeters. No target is used except at river crossings.

Value of level divisions.—Before commencing operations the constants of the instruments will be determined. The most important of these is the value of one division of the level tube. This can best be determined by means of a level trier. It can also be determined in the field as follows:

Set up the instrument firmly, mounting it on a wooden post, if possible, or better still, on a stone pier. Set up a rod in its tripod at such a distance that it can be distinctly read through the telescope. The distance should be at least 50^{m}, or, if the air is very still, 100^{m}, and should be carefully measured. Adjust the instrument carefully, taking such length of bubble in the level tube that its ends will be about the middle or tenth graduated line on each side. Direct the telescope to the rod and by means of the elevation screw cause the bubble to run to near one end of the level. Carefully note the position of the three wires on the rod and the reading of the level. Now, by means of the elevation screw, cause the bubble to run to near the other end of the tube and note the reading of the wires and bubbles as before. One result for value of one division of level can then be obtained. This operation should be repeated ten times. The elevation of the rod should be changed occasionally between sets in order to avoid estimating the same part of the same centimeter on the rod. It will be sufficient to run the bubble five divisions each side of its central position.

If k = distance from instrument to rod, in millimeters, d, d^1 = distance through which eye and object ends of bubble move when run from near eye-end to object end, $\frac{d + d^1}{2}$ = amount of displacement of bubble between two readings, r, r^1 = corresponding means of three thread readings on rod, and v = value of one division of level in seconds of arc, v^1 = value of one division of level in millimeters per meter.

Then $v = \frac{2\,(r^1 - r)}{k \sin 1'' \,(d + d^1)}$, and $v^1 = \frac{2{,}000\,(r^1 - r)}{k\,(d + d^1)}$.

Tables.—With the value of one division of the level tables will be constructed showing the correction to be applied to a rod reading for an observed inclination of the level and for a distance determined by interval between extreme threads.

If the level bubble is well ground equal displacements of the bubble, say of two divisions, will correspond to equal displacements on the rod.

Level fastenings.—Before using the level or determining its value the fastening of the tube in its case should be examined. One end should be clamped down just tight enough to prevent the tube from moving easily but not tight enough to strain

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the glass. The other end should be lightly clamped so that the tube may be free to expand and contract with temperature changes. The cotton packing at the ends should not exert a lateral strain on the tube. All level tubes will be numbered and have their numbers marked upon them.

Inequality of telescope rings.—In order to determine the inequality in the telescope rings the instrument should be mounted on a stone pier or other firm support and carefully leveled. The ends of the horizontol bar directly under the wyes should be firmly supported by blocks or large nails to prevent motion of the instrument in a vertical plane. The level should be carefully adjusted and the instrument clamped to prevent its moving in azimuth. Now, with the eyepiece of the telescope over the elevating screw, note the reading of the bubble when level is set on telescope, both in direct and reversed position. Now reverse the telescope in the wyes and read the level as before. Several sets of observations should be made.

Let b, b^1 = inclination of telescope as denoted by means of level readings with telescope direct and reversed, then the inequality of rings $p = \left\{ \frac{b - b^1}{4} \right\} v^1$ = value of the inequality of rings in millimeters per meter.

Sixteen determinations of the value of p of two instruments in use on the lake survey gave probable errors of $\pm$ 0″.046 and $\pm$ 0″.041.

The inequality may be expressed in seconds of arc if desired, but for purposes of computation is best expressed in millimeters per meter, as it can then be combined directly with the errors of adjustment of level and collimation.

Centering of object-glass.—The centering of the object-glass will be examined. This may be done as follows:

Draw out the eyepiece until the threads are no longer visible. Direct the telescope upon some well-defined object, and while looking at it rotate the telescope in its wyes; if the object remains steady the object-glass is sufficiently well centered. Should the object appear unsteady the fault can only be remedied by a maker. The objective should be firmly screwed into the telescope.

Wire intervals.—The values of the wire intervals will be determined as follows: Set up a rod at carefully measured distances of 10^m, 20^m, 30^m, 100^m from the instrument. Read the rod ten times at each distance. The rod may be altered in elevation, the level may be caused to change, and the telescope may be rotated 180° (inverted) in order to change the position of the wires, or threads, on the rod.

Taking the mean of the ten observed differences of readings of the extreme threads at each station occupied by the rod, a table will be constructed giving in meters the distance of the rod from the instrument for any observed difference of reading between extreme wires.

Length of rods.—Unless the rods used have been previously compared with some known standard they will be compared with each other and their relative lengths determined. This may be done by establishing two fixed points, or two foot plates, at equal distances from the instrument and differing in elevation about 2.7^m. The distance should be about 10^m. Determine the difference of elevation of the points by reading each rod on each point. A comparison of the resulting differences of elevation will give relative lengths of meters on rods. Ten measurements with each rod will be determined. The elevation of the instrument will be slightly changed between each set in order to eliminate errors in estimating the millimeters. Each rod will be numbered and have its number marked on it. The rods should also be kept dry and provided with canvas covers to protect them while being carried to and from work.

The distance, which will be called A, between the zero of graduation of the rod and the bottom of the steel spur on which the rod stands will be carefully determined; this distance should be made exactly the same for each pair of rods by filing off the steel spur if necessary. This may be determined by measuring the distance between bottom of spur and zero or first graduation on rod by the use of a right-angled triangle and scale. It may also be determined by means of another leveling rod, the graduations of which commence at the foot of the rod, by determining the height of the instrument above some fixed point and subtracting it from the reading of the rod to be determined. The relative lengths of the rods must be known.

Whenever a bench mark is connected with in such a way that the rod is not placed directly on the B. M. this quantity A enters into the computation of difference of elevation.

Adjustments.—Before commencing work at any time all adjustments will be carefully made.

The telescope will be collimated by having a rod set up at a distance of 50^m and noting the position of the wires on the rod when the telescope is normal and the bubble centered, and when inverted or rotated 180° about its axis and the bubble centered, then repeat with instrument in first position.

Let r = mean rod reading when the telescope is normal.

Let r^1 = mean rod reading when the telescope is inverted.

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Let D = distance in meters from instrument to rod. Then collimation error $C = \frac{r^1 - r}{2D}$ in millimeters per meter.

The collimation error of the mean of the horizontal threads should not exceed 0.025mm per meter.

The horizontality of the horizontal wires will be examined by moving the telescope in azimuth so that the rod shall appear to move through the field of the telescope. If the threads are horizontal the reading on the rod will be the same, the position of the level, which should be closely watched, remaining the same. If the threads are found to be not horizontal they will be made so by turning the telescope a small amount in the wyes. When the thread wires have once been made horizontal, small screws which abut against projection of wye above elevating screw should be so adjusted that when they press against this projection the wires are horizontal. If the vertical thread is then inclined, as shown by the plumb line attached to the rod, it must remain so.

To adjust the striding level, i. e., to make the tangent of the level tube parallel to the upper surface of the telescope rings, it is necessary to make a lateral adjustment and a vertical adjustment as follows:

To make the lateral adjustment, raise the clips fastening the level to the telescope and revolve the level about the telescope a short distance each side of the vertical. If the bubble runs in opposite directions when on opposite sides of the vertical, the level is to be adjusted by means of the opposing horizontal screws at one end of the level until such is not the case.

To make the vertical adjustment, set up a rod at a distance of about 50 meters and read the wires with the telescope normal, level direct, and the bubble in the center; reverse the level, center the bubble, and read the rod; then read the rod, with the level in the first position, to ascertain if any changes have occurred during the observations. Be careful to eliminate parallax when reading the bubble in the mirror.

Let r = mean of rod readings with level direct.

Let r^1 = mean of rod readings with level reversed.

Let D = distance in meters from instrument to rod.

Then error of inclination, $I = \frac{r^1 - r}{2D}$ in millimeters per meter.

This error is to be adjusted by the opposing vertical screws at one end of the level case. The error of adjustment must not be allowed to exceed two divisions of the level. Care must be taken that the telescope rings are free from dust while adjusting the level. After having made the vertical adjustment it will be necessary to examine the lateral adjustment again, since making one of these adjustments affects the other.

To make the tangent of the level tube and vertical axis of revolution perpendicular to each other, loosen the small clamp screw at one end of the horizontal bar fastened to the vertical axis and by means of the elevating screw raise or lower that end of the upper horizontal bar until the telescope can be rotated 180° from any position and have the level reading the same in both positions.

To adjust the level attached to the rod, set up the rod in its tripod in such a position that when a plumb line is attached to the small hook near the top of the rod the point of the plumb bob shall coincide with the point of a small cone attached to the rod near its foot. Now bring the level bubble to the center by means of the leveling screws. In making this adjustment the rod should not be exposed to the wind, as the plumb line is influenced thereby. This adjustment will be made at least once each day.

Setting up the instrument.—Each time that the instrument is set up at a station its axis will first be made vertical by means of the leveling screws in such manner that the telescope may be turned around the horizon without the bubble of the level running a great number of divisions. The telescope is finally made horizontal by means of the elevating screw. The bubble must be in the center at the moment of observing.

Sheltering the instrument.—The instrument when in use ought always to be sheltered from the sun and wind. It is carried from station to station without being dismounted, but the level should be taken off and carried in the hand. The small clamp screw at the end of horizontal bar and the large screw which fastens the instrument immovably to the tripod should both be turned tight before moving the instrument.

Holding rods.—The rods must be placed on the plates or pins which accompany them and held in a vertical position as indicated by the spherical level attached. It is advisable to always use the same rod with the same foot plate. In placing the foot plates, great care should be taken that they be horizontal, on firm ground, and not liable to change. The surface of the ground, if not firm or level, should be removed. When pins are used in hard ground they should not be driven down hard,

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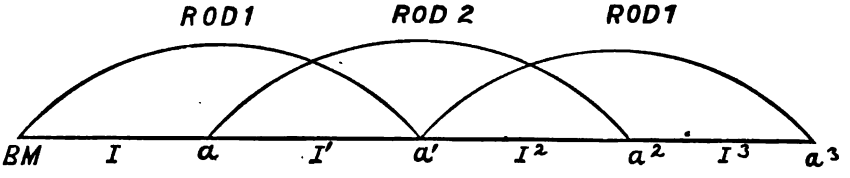
but only far enough to be stable; they will rise during observations if they are driven hard.

Errors of adjustment.—The errors of adjustment of collimation and inclination will be determined at beginning and end of each series of observations—that is to say, after having mounted the instrument and before dismounting it, and in all cases at least once each day. If the instrument has been deranged by a jar the corrections must be determined anew.

The algebraic sum of the errors of adjustment must not exceed two level divisions, and commonly should not exceed one. All the details of the determination of the errors of judgment must be entered in the notebook in their proper place. It is always advisable to have the errors of adjustment as small as possible, and necessary that they be well determined. The time of making these determinations will be recorded in the notebook.

Duplicating work.—In all work along the main line of levels each observer will duplicate his own work by running over the line in opposite directions, preferably under similar conditions as to illuminations, etc.

Order of using rods.—While connecting two bench marks the order of using the rods will be as follows:



In the above figure let I, I^1, I^2, etc., represent the successive stations occupied by the instrument. B. M., a^1, a^2, etc., occupied by rod 1, and a, a^2, etc., the positions occupied by rod 2. The instrument being set up at I. Rod 1 is placed on B. M. and rod 2 at a, making the distance I–a equal to I–B. M. Rod 1 is then read and immediately afterwards rod 2. The time elapsing between these readings should not exceed five minutes and commonly will not exceed one minute. The instrument is then carried to I^1, and rod 1 to a^1, the distance a–I^1 and I^1–a^1 being equal. Rod 1 will then be read and immediately afterwards rod 2.

The instrument will then be taken to I^2 and the rods read in the order 1, 2. Work will be continued in this manner until the other bench mark is reached. Rod 1 must be placed upon this bench mark, which will be the regular order if there have been an even number of instrument stations. If there have been an odd number of instrument stations, at the last station use rod 1 for both backsight and foresight.

If the lengths of meters on rods are the same and the values of A of the rods are equal, the stretch may be closed on either rod. While leveling, the rate of progress in favorable weather will be about 1 kilometer per hour.

In order to reduce the discrepancies due to settling of the instrument, the order of reading the rods will alternate. That is, at I the backsight will be read first and then the foresight; at I^1 the foresight will be read first and then the backsight, and so on throughout the length of the line.

Order of observing.—After having properly leveled the instrument at any station, always making the vertical wire occupy the same relative position with regard to the center line of the rod, the observations will be made and recorded in the following order: The bubble of the level being kept in the center while threads are being read. First read the level, then the position of the threads on the rod will be read, the millimeters being estimated, and finally the level will be read again. The observer will then read the rod a second time to make sure that no error has been made. The recorder will then take the differences between the readings of the middle and extreme wires to guard against errors, and if these differences denote any error the observations must be repeated. If an error exists, it will be shown by too great a difference between the differences. This is a most important check and must not be neglected. These differences will also serve as a check upon the distances between the instrument and rods.

The recorder should also check the level readings, when bubble is not centered, to make sure that errors of whole divisions have not been made. This may be done by summing up the readings and noticing the length of the bubble.

Reading level.—In reading the level by means of the mirror, care should be taken that the position of the eye is such that there will be parallax. Such positions can be determined once for all when the mirror is at its greatest angle of elevation, by a second person reading the level directly while the observer finds the position from which the reading of the level in the mirror is the same.

Form of field notes.—The notes will be kept in the form given in notebooks, as shown in the sample below. When once a number has been written down it must

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not be erased or made illegible. If wrong, a line will be drawn through it and the correct number written above. (Left-hand page.) Date, October 22, 1898.

Backsight.

Thread readings.	Means.	Difference of threads.	Level.		Rod.	Remarks.
			Eye.	Object.		
1196		128				
1324	1320.3	117	15.5	15.5	18	T. B. M. 249.
1441		245				

Observer, W. S. Williams. Recorder, E. E. Whitehead. (Right-hand page.) Level No. 4. Tube No. 214 Fauth.

Foresight.

Thread readings.	Means.	Difference of threads.	Level.		Rod.	Remarks.
			Eye.	Object.		
1068		127				
1195	1192.0	118	15.5	15.5	19	
1313		245				

Length of sights.—The lengths of sights taken will depend upon the condition of the atmosphere, but the rod should always be near enough to be seen distinctly. It will be seldom that lengths of sights greater than 100 meters can be taken. The backsight and foresight corresponding to any instrument station must not differ in length by more than 4 meters and the sum of the lengths of the backsights and foresights between any two bench marks should be equal.

If the observer has the slightest cause to think the instrument has been in the least disturbed, or that the refraction has changed between the times of reading the two rods, he should repeat the observation until satisfactory results are obtained.

Crossing streams.—Whenever it is necessary that the line of levels should cross a river or other wide obstruction, a narrow place should be chosen. Firm points should be set upon the two banks, levels in good adjustment are set up on opposite sides of the stream about 10 meters from each bench mark, and both levels go through the same operation. The distant rod will require a target. Each observer first reads on the bench mark nearest him, once with the telescope normal and level direct and once with the telescope inverted and level reversed; then takes simultaneous readings on the rod across the river with the instrument in the following positions:

1. Telescope normal, level direct.
2. Telescope normal, level reversed.
3. Telescope inverted, level direct.
4. Telescope inverted, level reversed.
5. Telescope inverted, level reversed.
6. Telescope inverted, level direct.
7. Telescope normal, level direct.
8. Telescope normal, level reversed.

These eight readings constitute one set for the direct run. Then take eight more readings in the same order for the reverse run, then each observer turns to the nearest bench mark and reads as he did at the beginning. Observers and instruments change places and repeat the observations at these new stations. The simultaneous levels eliminate refraction; the change of station eliminates curvature and small instrumental errors for each individual instrument. Unless good results are obtained the observations should be repeated until the results obtained come within the prescribed limits of error. If but one level can be used the operation will be performed in the same order, but the time occupied in crossing must be as small as possible.

Permanent bench marks.—Permanent bench marks will be established at intervals of 3 miles along the river and 5 miles on lines connecting the river line proper with the other levels or bench marks.

These bench marks will consist of a thoroughly vitrified tile 4 by 18 by 18 inches, placed 3 feet below the surface of the ground and surmounted by a 4-inch wrought iron pipe as a surface mark. The tile should have time to settle before leveling to it. Both tile and pipe will be suitably marked to designate the character of the point. In the center of the upper surface of the tile a copper bolt will be leaded, the upper surface of which will be the point of reference. These bench marks will be placed

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where they can be easily found and where they will not be disturbed. Property corners should be utilized where practicable.

In addition to the above, benches should be established on permanent brick or stone structures by leading into them a horizontal or vertical copper bolt with the letters U. S. P. B. M. cut near it. A small hole in the center of the bolt will be the point of reference.

Connecting with bench mark.—In connecting with a bench mark, if the bolt is vertical the foot of the rod is placed directly upon it. If the bolt is horizontal in the wall of a building or other structure, it will be connected with in the following manner: Set up the instrument in such a position and at such an elevation that the small hole in the bolt may be bisected by the middle thread without displacing the level by more than five divisions, using the elevating screw for making this bisection. Since the instrument can be raised or lowered about 2 centimeters by means of the leveling screws, the instrument can be placed in such a position by two or three trials.

Now bisect the bench mark with the telescope normal and also inverted, noting the reading of the level. Read the rod on the plate with the telescope in both positions and the bubble in the center. It is necessary to eliminate collimation of the middle wire by inverting the telescope, since the collimation of the middle wire is not the same as that of the three wires. The quantity A (distance between the zero of the rod and the bottom of the spur) must be taken into account when a bench mark is connected with in this manner. The distance of bench mark from instrument must be determined and recorded.

Closing work for the day.—Whenever work is stopped at least two temporary bench marks should be established. These will consist of large nails or spikes driven their entire length vertically into the base of trees or in the tops of sound stakes. The mean elevation of these two benches will be used in continuing the work.

Describing bench marks.—Every bench mark will be fully described in the notebook and a careful sketch will be made of its surroundings. Its position with reference to the most prominent objects near it should be given by distance and direction. Public buildings, such as depots, court-houses, churches, etc., are the best positions for permanent bench marks. In a village or town several permanent bench marks should be established to insure at least one being always available.

Determine elevation of base of rail.—If a railroad is crossed the elevation of the base of the rail will be determined, and if leveling along a railroad the elevation of the base of the rail at depots will be determined.

Gauge zeros.—The elevation of the zeros of all water gauges and also the gauge bench marks will be determined.

Datum planes of cities.—The main line of levels will be connected with the datum planes of cities along the line and the elevations of these planes will be deduced.

United States Engineer bench marks.—The main line of levels will be connected with all accessible important United States Engineer bench marks.

In reducing the observations the nearest tenth of a millimeter will be retained. The distance will be taken out from the table to the nearest meter.

The limit of discrepancy in closing a polygon will be: $3^{mm}\sqrt{}$ distance in kilometers.

The distance referred to is the entire length of the polygon from B. M. 1 to B. M. 2 and back to B. M. 1, and the limit of discrepancy refers to the polygons between successive bench marks. If the discrepancy exceeds the prescribed limit then the entire line must be rerun one or more times, or until the difference of the direct and reverse results is within the limit. In rerunning lines the third line run should alternate between direct and reverse directions so as to keep the total number of direct and reverse lines equal.

Field reductions of all precise level notes will be made and checked at the end of each day's work, so as to ascertain before leaving the ground whether the results come within the prescribed limits.

APPENDIX 1 F.

REPORT OF MR. KIVAS TULLY, ASSISTANT ENGINEER, ON GAUGES, REDUCTION OF PHYSICAL DATA, AND OFFICE PUBLICATIONS.

ST. LOUIS, MO., *May 31, 1899.*

CAPTAIN: I have the honor to submit the following report of the work pertaining to gauges, reduction of physical data, records, and office publications since May 31, 1898.

REGULAR GAUGES.

The regular gauges maintained by the commission comprise 14 on the Mississippi River between St. Louis, Mo., and the Head of the Passes, Louisiana; one on the St.

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Francis River at the St. Louis, Iron Mountain and Southern Railway Bridge; one on the White River at Clarendon, Ark., and one at Barbre Landing near the head of the Atchafalaya River. A self-registering tide gauge is maintained by the commission near Biloxi, Miss.

All the gauges on the main river have been inspected by a party on the U. S. steamer *Patrol*, in charge of Surveyor E. L. Harman, during November, 1898, to February, 1899, inclusive, as follows:

Cape Girardeau, Mo.—This gauge was inspected November 14, 1898, at a stage of 9.84 feet, which was about 7 feet above the lowest reading of the season. The temporary section 8.5 to 16 feet was 0.06 foot low. Upper sections were practically correct. A new section reading from 6 to 10 feet was set. A new bench mark was established and the bulletin plates were painted.

The office hydrographs indicated errors in dates in February and March, 1898. These were corrected by comparison with gauges in the vicinity.

Belmont, Mo.—This gauge was inspected November 19, 1898, at a stage of 18.9 feet. The sections above water were found practically correct; the lower sections could not be checked.

New Madrid, Mo.—This gauge was inspected November 23, 1898, at a stage of 15.08 feet. The section 11 to 20 feet was found 0.1 foot low; the section 37 to 41 feet was 0.05 foot high; other sections above water were practically correct. As the sections were supposed to be firmly fastened to their supports no change was made at the inspection. On February 4, 1899, the observer reported the section 11 to 20 feet washed out in the January rise. The bulletin was cleaned and painted at inspection.

Cottonwood Point, Mo.—This gauge was inspected November 26, 1898, at a stage of 12.04 feet. Section 11 to 18 feet was found 0.13 foot high; section from 26 to 31 feet was missing; other sections above water were practically correct. An inclined section reading from 13.2 to 36 feet following the slope of bank was built. The upper end of this gauge was drift bolted into the root of a cottonwood tree at top of bank. A vertical section reading from 7 to 14.8 feet was also set. Some painting and repairs were done on bulletin.

The inclined gauges constructed during the year consist of sloping stringers 5 by 5 inches or 4 by 6 inches laid upon the surface of the ground, supported by 8 by 8 inch posts set into the ground about 5 feet, the horizontal distance between posts being from 8 to 10 feet. The stringers were gained into and firmly bolted to the posts.

Fulton, Tenn.—This gauge was inspected November 30, 1898, at a stage of 12.06 feet. Sections 12 to 16 and 16 to 23 feet were found 0.05 and 0.08 foot low, respectively; other sections above water were practically correct. Gauge was rebuilt from 8.4 to 16 and 22 to 36 feet. Bulletin was raised and left in good order.

Mhoon Landing, Miss.—This gauge was inspected December 7, 1898, at a stage of 6.07 feet. The temporary section in use was found to be 0.31 foot low. The observer had been using temporary sections since June 9 last. To avoid the caving bank at this site the gauge was moved upstream about 1,400 meters and rebuilt. The original site of this gauge is about 500 meters still farther upstream, and sections have been moved up or down stream from time to time, but the same elevation of the zero has always been maintained. The new gauge extends from 0 to 45 feet. Two additional tree bench marks were established. The bulletin was moved up to new gauge site.

Sunflower Landing, Miss.—This gauge was inspected December 13, at a stage of 11.25 feet. Section 33 to 38 feet was found to be 0.07 foot high; the sections above water that had been used by observer were practically correct. The inclined gauge was rebuilt from 15 to 38.5 feet December 15. The bulletin was moved, set in front of the old Sunflower warehouse, and left in good order.

Arkansas City, Ark.—This gauge was inspected December 24, 1898, at a stage of 11.43 feet. The lower end of temporary section in use was found to be 0.1 foot high. The sections below 22 feet had been destroyed by the removal of piling to which they were fastened. The errors found in temporary gauges did not sufficiently account for the large discrepancies in gauge readings as shown on the office hydrographs. Probably the temporary sections had been disturbed before the arrival of inspector. The discrepancies probably arose from errors in reading gauge by a substitute observer, as they reappeared immediately after the December inspection. The inspector visited the gauge again February 20, 1899, but the water was then above the part of the gauge in question; nothing could be learned from the observer to explain the large discrepancies, amounting to 2.7 feet on December 30; after that the record was apparently correct. The records from September 11 to December 30, 1898, were corrected by coordinate plats from Greenville and mouth of White River gauges. The gauge was rebuilt at December inspection from 8 to 41 feet. The bulletin was repainted and left in good order.

Greenville, Miss.—This gauge was inspected December 27, 1898, at a stage of 10.72 feet. The temporary section found in use and other sections above water were practically correct. The bank at gauge site was being graded for improvement

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work and a temporary site was selected about 330 meters downstream, where an inclined gauge was constructed by nailing 2 by 6 inch strips on ties of tramway of elevator of Vicksburg and Greenville Packet Company; this reads from 11.4 to 43.5 feet. A section of 43 to 50 feet was put up at old site. Bulletin was moved to top of levee and the plates retouched.

St. Joseph, La.—This gauge was inspected on December 30, 1898, at a stage of 9.28 feet. The temporary section in use, 6.5 to 11 feet, was correct, as was also the high water section, 39 to 49 feet. Other temporary sections were from 0.02 to 0.07 foot in error. An inclined gauge was partly built from 10.2 to 39.4 feet, and was finished on return visit in January. A vertical section was built from 49 to 51 feet. The bulletin board was raised above high water and painted.

Bayou Sara, La.—This gauge was inspected January 4, 1899, at a stage of 12.12 feet. The temporary section in use, 10.3 to 14 feet, was 0.11 foot low. The section 7 to 12 feet was 0.07 foot low. Other sections above water were practically correct. Gauge was rebuilt from 10 to 19 feet and from 24 to 34 feet. Bulletin was repainted.

Plaquemine, La.—This gauge was inspected January 6, 1899, at a stage of 12.71 feet. The observer had been reading temporary sections at upper landing about 600 meters above regular gauge site since June, 1898; the section found in use read 0.85 foot too low. It was assumed the error accumulated since September 6, 1898, as it was found correct about that time by the lock engineers. New sections were built at the regular site, reading from 8 to 15 feet and 24 to 28 feet vertical, and an inclined gauge from 14.2 to 24.2 feet. Some bulletin plates were repainted.

College Point, La.—This gauge was inspected January 7, 1899, at a stage of 10.13 feet. The section found in use, 6 to 11 feet, was 0.07 foot low; the section 14 to 24 feet was 0.09 foot high; other sections were practically correct. An inclined gauge was built 10 to 22.2 feet, and the bulletin was painted. This inclined gauge was reported by gauge observer under date of April 4, 1899, as having been destroyed by high water.

Fort Jackson, La.—This gauge was inspected January 13, 1899, at a stage of 3.8 feet, and was found correct.

On the return trip of the inspection party the gauges at and below Mhoons Landing were again visited, the bench marks examined, and data collected for revision of the printed descriptions. The gauge records have been corrected in accordance with the inspection levels. The gauges on the St. Francis and White rivers were not inspected, the rivers having risen past low-water stages when the main river was finished.

Tables Nos. 6 and 7 give the maximum and minimum readings on all available gauges for 1898 and previous highest and lowest.

HIGH-WATER GAUGES.

The commission maintains 182 of these gauges between Cairo and Fort Jackson, La. These are fully described in Report of Chief of Engineers for 1896, page 3536.

These gauges were inspected by the party on the *Patrol* from Cairo to Greenville, Miss., during November and December, 1898, and from Fort Jackson to Greenville in January and February, 1899. All were repaired or rebuilt and left in good order. Five new gauges were erected, designated 8^a, $20\frac{1}{2}$, 51^a, 62^a, and 90^a. The old gauges No. 8 and No. 90 will be discontinued and records continued on new gauges of corresponding number distinguished as above. The observers were supplied with postal cards and instructed to report the highest reading, also to drive a nail in gauge at highest point reached by the water of this year. The maximum readings of the high water of 1899 are given in table No. 8 as far as reports have been received, also the highest readings of all the regular gauges below Cairo. The high water of 1897 is also given for comparison.

BILOXI TIDE GAUGE.

The purpose for which these tidal observations were undertaken was primarily to furnish a plane—that of mean sea level in the Gulf of Mexico—to which the elevations of all bench marks of the survey of the Mississippi River could ultimately be referred.

Biloxi Bay was selected as a location after full consideration of stability of soil, possible influence of river stages, and other conditions. That the choice was a judicious one is indicated by subsequent tidal observations near the mouth of the river, made for a different purpose, which show unmistakable effects of the high stages of the river. The location at Biloxi is open to the Mississippi Sound and to the Gulf, and there is every reason to regard it as a favorable point for determining the Gulf level. Tidal observations were made at Cat Island in 1848-49 by the United States Coast Survey, and show about the same range and character of tides as appear in the present records. A full discussion of tidal phenomena of the Gulf of Mexico by Mr. William Ferrell, assistant, United States Coast Survey, will be found in appendix to Report of the Coast Survey for 1874.

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The Biloxi gauge was located at the bridge of what is now the Louisville and Nashville Railroad over Biloxi Bay in September, 1881, and has been maintained there during all the observations. A sketch map—plate No. 9—shows the location of the Biloxi gauge and also the locations of the gauges at Port Eads and East Bay. The records of the last two stations have been obtained through the courtesy of Maj. James B. Quinn, Corps of Engineers, U. S. A. Hydrographs of all these stations and that of the river gauge at Red River Landing are shown on Plate 8. They are given mainly to show the characteristic features of the different stations regardless of absolute elevations. It will be noticed that Biloxi, representing the Gulf, has a different period of high water from the river station at Red River Landing. The other stations seem to be resultants of these two influences. Especially is this noticeable in the Port Eads record, and it therefore seems evident that this gauge should not be used as a standard of Gulf level in comparison with Biloxi during high stages of the river. No reference will be made, except at Biloxi, to absolute elevations of water surface at the different stations, as it has been decided to defer a discussion of this question until after the connecting levels are rerun the coming season.

Since the complete results of the Biloxi observations are now presented for the first time the following memoranda of the apparatus used and methods employed in the reduction are given:

A self-registering tide gauge was made for the Mississippi River Commission; was designed by Mr. R. S. Avery, of the tidal division of the United States Coast Survey, and made under his supervision by Fauth & Co., of Washington, D. C., early in 1881. The apparatus was similar to that fully described and illustrated in Appendix No. 8, Report of the United States Coast Survey for 1876, page 130. It consists of a float inclosed in a vertical wooden box or tube, the float rising and falling with the water surface, the water being admitted to the box by a contracted opening at the bottom. The float is suspended by a cord which passes over a grooved wheel called the float wheel. The periphery of this wheel is directly over the float box. The wheel is mounted on a steel shaft to which is clamped a smaller wheel with a counterpoise for the float attached to it. The shaft also carries and revolves a small drum; this drum, by means of a small chain and pulleys, causes a pencil carriage to slide back and forth parallel to the axis of a large cylinder on which is wound the paper tide roll, the cylinder being revolved by clockwork at a uniform rate. The coordinates of the curve traced by the pencil on the paper, which is in a continuous roll about 13 inches wide, is the *time* which is furnished by the revolving cylinder moved by the clock, and the *heights* of the water surface, which is given by the recording pencil moved by the float. The actual rise and fall of the tide is shown on the tide roll or maregram in the ratio that the drum bears to the float wheel, which was 1:5.

A staff gauge was also used in connection with the self-registering gauge. By reading the staff and noting the time on the maregram the latter can be referred to zero of the staff gauge, which is connected by levels with bench marks on shore; thus absolute elevations of tide readings are established. This apparatus was installed on the draw pier of the railroad bridge before mentioned. The record began in August, 1881, and was continued, with some interruption due to stoppages of the clock and other causes, until June 10, 1885, when the first series was closed and the apparatus shipped to the St. Louis office. This gauge was at the draw pier, where first placed, until January 30, 1884, when it was moved to a group of piles at the northwest end of draw span when open, where it remained to the end of the first series; another gauge was established at the same place for the second series.

On June 21 and 22, 1882, the precise-level party of the commission closed the line from New Orleans at Biloxi and established permanent bench marks on the west shore of the bay. The 8-foot mark of the staff gauge was connected with the bench marks of the precise levels and elevation of zero of staff deduced therefrom. This staff gauge and bench marks were again connected by levels in January, 1884. No discrepancies were found. A new staff was set at the new site with its zero presumably at the same elevation as that of the old staff gauge. By leveling to it in June, 1884, the zero of this new staff was found to be of the same elevation as that of the old staff gauge.

The self-registering tide gauge selected for the second series of observations, which began October 29, 1895, was that designed by A. Stierle and manufactured by H. Bilgram, Philadelphia, Pa. This instrument is very compact. While it is not claimed for it that the principles of its construction are new, its details are very complete and its run has been almost continuous, except when changing the paper, since its installment. A description of its establishment, with illustrations of its exact location, also of the float box and a micrometer device for reading the staff gauge designed by Mr. J. A. Ockerson, is given in Report of Chief of Engineers for 1896, page 3572. The vertical scale of the maregram is 1:12.

In establishing the new staff gauge in October, 1895, it was intended to set its zero at the same elevation as that of the former gauge, but owing to discrepancies

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in the bench marks used it was set slightly higher. In April, 1898, precise-level connection was made between this gauge and all available bench marks in the vicinity. From the finally adopted values for the most permanent of these bench marks the new staff was found to be 0.055 foot higher than the former staff gauge.

OBSERVATIONS.

The observations of the first series were made by the different bridge tenders until June, 1884, when Mr. F. B. French, an assistant from this office, was placed in charge and remained until April 20, 1885, when a bridge tender again assumed charge. In the first series the time notes and staff reading are deficient, except while Mr. French was in charge of the gauge. Interruptions in the records are frequent. Especially is this the case in 1883, only one month of that year being sufficiently reliable for use.

The observations of the second series have been made by the bridge tender, L. B. Vanderpool, who is still in charge of the gauge. The records of this series are very complete and satisfactory, both as regards time notes and staff readings, and the maregram is practically continuous.

REDUCTION.

Before beginning the final reduction the methods employed by the Coast Survey were examined by the writer in the tidal division of that office and have been closely followed in this work.

The tide roll of the first series being on a large scale ordinates were scaled off at half-hourly intervals. The record of the second series being on a smaller scale and more regular, on account of a better arrangement of opening in float box, the ordinates were taken at hourly intervals. These ordinates were tabulated. From them the monthly means were computed and are given in Table No. 9, reduced to the present staff gauge. These tabular means show that the Gulf level is highest each year in the early fall months. A comparison of barometer readings and of wind records at New Orleans and Mobile, which were the nearest stations available, failed to explain this. On account of these inequalities in the monthly means only yearly means have been used in deducing the final value for mean Gulf level, which is, as given in Table No. 9, 6.0829 feet, with a probable error of $\pm$ 0.0114 foot, computed from five yearly means. A description is given herewith of the bench marks at Biloxi Bay and their elevations with reference to the zero of the present staff gauge.

The so-called preliminary value of mean Gulf level heretofore used in this office was derived from the records of this gauge during the period from May 28 to October 13, 1882. This period was selected as being presumably free from the disturbing influences of northerly winds. This value reads 6.401 feet on the present gauge, and is 0.318 foot higher than the final value. The difference between the preliminary and final value arises mainly from the fact that during the months used in obtaining the preliminary value the Gulf level is always higher than the mean of the year.

The value for mean Gulf level used by the Coast Survey was derived in that office from records of the same gauge covering a longer period in 1882 and part of 1881. This value reads on the present gauge 6.175 feet, and practically agrees with the value found for the same period by the final reduction. The Coast Survey offer, as a rough estimate of the probable error of this value, 25 millimeters. See Report of the Coast Survey for 1887, page 198, for further details.

It is apparent from the foregoing that there is no real conflict between the different values of mean sea level at Biloxi; the discrepancies arise from the fact that different periods of time were used in deducing these values. The value here given as final, being deduced from five complete years, seems entitled to the greatest weight, its probable error being about 3½ millimeters as against an estimated error in the Coast Survey value of 25 millimeters.

A hydrograph sheet is appended, plate 8, showing monthly means for each year and the final mean drawn as a horizontal line.

COMPREHENSIVE HYDROGRAPH.

A comprehensive hydrograph of the main river and tributaries, plotted to a small scale, for a period of 28 years, has been commenced and is about half completed. It has been temporarily laid aside for more pressing work.

PHYSICAL DATA.

The party on the *Patrol* repaired and reestablished range hubs and signals at the regular discharge sections on the main river. A new section was selected and laid out at Thebes, Ill., about 45 miles above Cairo. The only river discharge measure-

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ments made this year were ten on the St. Francis River about 15 miles above its mouth, at a stage of about 13 feet above extreme low water. While on the gauge-inspection trip the party on the *Patrol* also examined many of the permanent marks of the general survey, in some cases replacing old stone marks with tile and pipe benchmarks; the elevations were determined and noted for future reference.

OFFICE PUBLICATIONS.

The following pamphlets have been prepared and printed.

Stages of the Mississippi River and Tributaries, for 1898, containing the daily readings of 34 stations on the main river and 24 on the tributaries. This also contains descriptions of gauge bench marks and elevations of gauge zeros and extreme high and low readings on these gauges to date. Records of three stations on the Upper Mississippi—Rock Island, Nashville, and Burlington—were added this year.

Highest and Lowest Annual Stages of the Mississippi River and Tributaries, to 1898. This gives also elevations of gauge zeros and distances from Cairo of all stations. This pamphlet contains 33 pages.

Descriptions, Elevations and Geodetic Positions of Permanent Marks, Cairo, Ill., to St. Paul, Minn., Survey of the Mississippi River. This pamphlet contains about 300 pages.

The monthly reports of operations of the secretary of the commission have been prepared and printed with the reports of the district officers.

The proceedings of the seventy-fourth, seventy-fifth, and seventy-sixth sessions of the commission have been printed, as have also the projects of secretary and district officers, acted on at those sessions.

A pamphlet of instructions for field work of triangulation, precise levels, topography and hydrography, gauge inspections, and discharge measurements was prepared and printed.

The professional records of the commission, comprising field notebooks, maps, boat drawings, and manuscripts, have been cared for and the card-index system kept up.

I desire to acknowledge the very able assistance of Mr. F. F. Axtell during the year, and also that of Mr. E. J. Thomas and Mr. W. C. Lemen during part of the year. These gentlemen have been most unremitting in their attention to and interest in the work of this division.

Very respectfully, your obedient servant,

KIVAS TULLY,
Assistant Engineer.

Capt. MASON M. PATRICK,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

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TABLE No. 6.—*Highest and lowest gauge readings of 1898; also previous highest and lowest.*

MISSISSIPPI RIVER.

Station.	Distance from Cairo.	Elevation of gauge zero above Cairo datum plane.	Highest.					Lowest.				
			Prior to 1898.		1898.		Difference compared with previous highest.	Prior to 1898.		1898.		Difference compared with previous lowest.
			Date.	Gauge reading.	Date.	Gauge reading.		Date.	Gauge reading.	Date.	Gauge reading.	
	Miles. Above.	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Hastings, Minn	892.6	690.79	Apr. 30, 1881	18.00	June 8	13.4	— 4.60	Nov. 28, 1892	—0.70	Nov. 27	0.5	+ 1.2
Winona, Minn	794.8	660.34	June 18, 1880	16.87	June 13–14	10.7	— 6.17	Dec. 30, 1889	—1.33	Sept. 27–30	1.5	+ 2.83
North McGregor, Iowa	688.8	625.32	June 22, 1880	21.5	June 19–20	10.0	—11.5	Aug. 16–17, 1894	.3	Nov. 26	.1	— .2
Rock Island, Ill	509.2	562.37	June 27, 1892	19.4	Feb. 14	9.9	— 9.5	Jan. 5–6, 1890	— .9	Nov. 30	— .4	+ .5
Burlington, Iowa	427.6	531.25	May 18–19, 1888; June 30, 1892.	17.6	Mar. 14, 15, 17	6.8	—10.8	Dec. 4–5, 1895	—1.1	Dec. 7	— .5	+ .6
Nashville, Iowa	393.6	516.86	May 17–18, 1888	12.0	Mar. 20	4.8	— 7.2	Jan. 7, 1890	— .5	Dec. 4–6	.2	+ .7
Hannibal, Mo	329.4	469.60	May 17, 1888	21.58	May 21	11.7	— 9.88	Jan. 9, 1890	—1.75	Dec 6	— .7	+ 1.05
Grafton, Ill	283.0	424.09	May 18, 1892	25.73	May 23	18.1	— 7.63	Dec. 9, 1895	— .9	Dec. 9–10	1.9	+ 2.8
St. Louis, Mo	190.8	400.23	May 19, 1892	a 35.95	do	27.20	— 8.75	Jan. 27, 1895	— .60	Dec. 11	.3	+ .9
Chester, Ill	115.5	361.30	May 21, 1892	31.2	May 24	22.2	— 9.0	Dec. 24–25, 1897	—1.9	Jan. 5	.1	
										Dec. 10	.3	+ 2.2
Cape Girardeau, Mo	54.5	324.97	Apr. 12–13, 1897	31.6	Mar. 28	27.8	— 3.8	Dec. 26–27, 1897	1.0	Dec. 15–16	2.8	+ 1.8
Grays Point, Mo	48.0	321.28	May 22, 1892	35.00				Dec. 31, 1880	.95			
	Below.											
Belmont, Mo	21.3	286.85	Feb. 26, 1883	45.58	Apr. 6	43.98	— 1.60	Nov. 6–8, 1895	.05	Oct. 10	7.68	+ 7.63
Morrisson Landing, Mo	69.0	275.80	Feb. 24, 1884	41.50				Nov. 11–14, 1879	— .17			
New Madrid, Mo	70.3	275.72	Mar. 29, 1897	40.27	Apr. 7–8	38.31	— 1.96	Nov. 6–8, 1895	.55	Oct. 10	6.43	+ 5.88
Cottonwood Point, Mo	122.5	250.67	Mar. 21–23, 1897	39.35	Apr. 8–10	38.53	— .82	Nov. 5–8, 1895	—3.35	Oct. 11	4.6	+ 7.95
Fulton, Tenn	175.4	228.55	Mar. 23, 1897	37.47	Apr. 10	38.30	+ .83	Nov. 7–8, 1895	.16	do	6.55	+ 6.39
Memphis, Tenn	230.0	203.97	Mar. 20, 1897	37.66	do	37.59	— .44	Nov. 6–9, 1895	—2.65	Oct. 12	4.50	+ 7.15
Mhoon Landing, Miss	277.3	181.48	Apr. 4, 1897	41.60	Apr. 14–16	39.10	— 2.50	Nov. 6–11, 1895	—7.80	Oct. 12–13	.80	+ 8.60
Helena, Ark	306.5	161.98	do	51.75	Apr. 17	49.10	— 2.65	Nov. 8–9, 1895	—3.00	Oct. 13	7.80	+10.80
Sunflower Landing, Miss	352.7	147.08	Mar. 27, 1897	47.17	Apr. 17–19	46.00	— 1.17	Nov. 12–14, 1895	—1.50	Oct. 13–14	8.5	+10.00
Mouth of White River, Ark	393.2	128.73	Mar. 29, 1897	52.42	Apr. 19	51.05	— 1.37	Dec. 28, 1872	.00	Jan. 12	12.70	
										Sept. 12	12.80	+12.80
Arkansas City, Ark	438.3	116.44	do	51.9	Apr. 19–21	51.2	— .7	Nov. 9–10, 1895	—3.6	Jan. 13	9.2	+12.8
Greenville, Miss	478.3	108.00	do	46.75	Apr. 21	46.20	— .55	Nov. 10–11, 1895	—2.55	do	7.20	
										Sept. 13	7.95	+10.50
Lake Providence, La	542.3	89.62	Mar. 30, 1897	44.54	Apr. 23	44.35	— .19	Nov. 17, 1895	—5.30	Sept. 14–15	6.75	+12.05
Vicksburg, Miss	599.3	66.04	Apr. 16, 1897	52.48	Apr. 23–25	49.40	— 3.08	Nov. 13–14, 1895	—6.5	Jan. 1	8.00	
										Sept. 14	8.57	+15.07
St. Joseph, La	648.3	52.74	Apr. 17, 1897	47.85	Apr. 25–26	45.10	— 2.75	Nov. 13, 1895	—9.3	Sept. 15	5.75	+15.05

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Natchez, Miss	700.2	36.39	May 2, 1897	49.82	Apr. 26–27	47.40	— 2.42	Nov. 13–15, 1895	— .85	Sept. 15–16	12.48	+13.33
Red River Landing, La	785.3	29.35	May 14–15, 1897	50.20	Apr. 28–30	44.30	— 5.90	Nov. 14, 1895	— .60	Sept. 16	9.46	+10.06
Bayou Sara, La	799.8	23.35	May 13–15, 1897	43.7	Apr. 27–May 1	37.5	— 6.2	Nov. 16, 1895	—2.7	Sept. 16–17	4.0	+ 6.7
Baton Rouge, La	833.3	20.06	do	40.65	Apr. 29–May 1	34.60	— 6.05	Nov. 14, 1894	.45	Sept. 17	5.41	+ 4.96
Plaquemine, La	854.1	21.06	May 18–17, 1897	36.25	do	30.5	— 5.65	do	— .94	Oct. 18	3.4	+ 4.34
Donaldsonville, La	885.4	19.48	May 13, 1897	32.75	Apr. 30	28.00	— 4.75	Nov. 11, 1894	1.00	Jan. 1	4.3	
										Sept. 17–18	4.42	+ 3.42
College Point, La	904.5	21.24	May 15, 1897	27.95	Apr. 27, 30	23.59	— 4.36	Nov. 14, 1894	— .91	Jan. 1	2.00	
										Sept. 17	2.28	+ 3.19
Carrollton, La	957.0	20.91	May 13, 1897	19.17	Apr. 25	15.90	— 3.27	Dec. 27, 1872	—1.60	Jan. 1–2	1.00	
										Oct. 29–30; Dec. 24–25.	1.80	+ 3.40
Fort Jackson, La	1,039.0	19.26	Apr. 22, 23, 29; May 14, 16, 1897	7.2	Apr. 23, 26	6.7	— .5	Dec. 7, 1893; Nov. 12, 14, 1894	.8	Jan. 2	.9	
										Dec. 26	1.8	+ 1.00

a High water of June 28, 1844, reads 41.4 feet.

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TABLE NO. 7.—*Highest and lowest gauge readings of 1898; also previous highest and lowest.*

TRIBUTARIES OF MISSISSIPPI RIVER AND THE ATCHAFALAYA.

River.	Station.	Approximate distance of station from—		Elevation of gauge zero above Cairo datum plane.	Highest.					Lowest.				
					Prior to 1898.		1898.		Difference compared with previous highest.	Prior to 1898.		1898.		Difference compared with previous lowest.
					Date.	Gauge reading.	Date.	Gauge reading.		Date.	Gauge reading.	Date.	Gauge reading.	
			Miles.	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Arkansas	Little Rock, Ark	Mouth	176	241.53	May 21, 1892	31.20	May 11	29.30	— 1.90	Oct. 22–24, 1879	— 1.00	Jan 5	4.00	
												Nov. 18–21	4.80	+5.80
Do	Pine Bluff, Ark	do	110	200.34	May 22, 1892	30.50				Nov. 20–23, 1887	— .40			
Atchafalaya	Barbre Landing, La	Head	0	24.17	May 13–14, 1897	50.95	Apr. 30, May 1–3.	42.8	— 8.15	Oct. 26, 1897	— 1.77	Sept. 17	7.10	+8.87
Do	Simmesport, La	do	4	24.17	May, 1897	49.22				Nov. 8, 1891	— 1.60			
Do	West Melville, La	do	27	20.17	Mar. 31, 1882	37.00	Apr. 29–May 4.	33.9	— 3.10	Nov. 12–13, 1894	1.0	Sept. 18	9.5	+8.5
Cumberland	Nashville, Tenn	Cairo	234		Jan. 22, 1882	55.30	Jan. 23	38.80	—16.50	Oct. 15–16, 1878	— .40	July 14	1.50	+1.90
Illinois	Peoria, Ill	Mouth	160		May 9, 1892	21.9	Mar. 31	19.3	— 2.6	Oct. 7, 1890	2.6	July 24	3.5	+ .9
Do	Beardstown, Ill	do	86	444.26	1882	21.3				Aug. 11–12, 1887	.00			
Missouri	Coles Creek, Mo	do	107	433.97	May 15, 1892	96.76	June 17	90.65	— 6.11	Dec. 24, 1897	70.7	Dec. 13, 14	72.20	+1.5
Ohio	Cincinnati, Ohio	do	504	447.62	Feb. 14, 1884	71.06	Mar. 28	61.1	— 9.96	Sept. 18, 1881	1.92	Oct. 5, 6	4.4	+2.48
Do	Louisville (upper), Ky	do	364	419.76	Feb. 16, 1884	46.60	Mar. 30	36.20	—10.40	Sept. 10–14, 18–22, 1881; Nov. 14–16, 1895.	1.70	Sept. 26	3.50	+1.80
Do	Louisville (lower), Ky	do	364	392.85	do	72.00	do	62.00	—10.00	Oct. 17–18, 1872	1.60	Oct. 8	4.30	+2.70
Do	Paducah, Ky	do	45	308.40	Feb. 23, 1884	54.25	Apr. 6	47.3	— 6.95	Oct. 30–Nov. 4, 1895.	— .7	July 22, Sept. 26, 27.	3.5	+4.2
Do	Cairo, Ill	do	1	290.84	Feb. 27, 1883	52.17	do	49.8	— 2.37	Dec. 24, 1871	— 1.00	Oct. 10	7.67	+8.67
Ouachita	Camden, Ark	Mouth Red River.	325	91.38	May 12, 1882	46.0	Jan. 25	33.6	—12.4	Aug. 29–30, 1887	1.80	Sept. 12–14	2.93	+1.13
Do	Monroe, La	do	175	51.22	1882	48.60	Feb. 12–13	35.9	—12.70	Sept. 24–Oct. 31, 1897.	.00	Sept. 13–15	.8	+ .8
Red	Fulton, Ark	Mouth	508	244.78	July 17, 1876	35.75	May 11	27.9	— 7.85	Oct. 20–22, 1896	.10	Nov. 7, 8	2.30	+2.20
Do	Garland, Ark	do	450	223.44	Mar. 24, 1894	28.50	do	27.7	— .80	Sept. 22–25, 1896	— .20	Nov. 8	1.35	+1.55
Do	Shreveport, La	do	320	161.27	May 28, 1892	35.70	May 21	15.0	—20.70	Dec. 2–4, 1894	— 5.50	do	.20	+5.70
Do	Alexandria, La	do	110	64.46	June 12–13, 1892	38.25	Jan. 23	17.40	—20.85	Sept. 29, 1881	3.7	do	—1.10	+2.60
St. Francis	Bridge St. L., I. M. & S. Ry.	do	194		Apr. 4–6, 1897	41.6	Apr. 17–19	34.1	— 7.5	Nov. 15–25, 1897	.8	Jan. 1–5	1.1	
												Sept. 29	3.0	+2.7
Do	Wittsburg, Ark	do	180		Apr. 28, 1886	42.02				Oct. 27–31, Nov. 10–14, 1892.	— 3.60			

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Tennessee	Chattanooga, Tenn	Cairo	475	651.90	Mar. 1, 1875	54.00	Sept. 5	24.6	—29.40	Sept. 11-14, 1881, and 19, 1883.	.00	June 15	1.6	+1.60
Do	Florence, Ala	do	275	418.06	Mar. 19, 1897	32.20	Jan. 20, 27-29.	13.80	—13.40	Oct., 1872, Sept. 18, 1878.	— .76	June 14, 19	.87	+1.13
Wabash	Mount Carmel, Ill	do	190	397.81	Aug. 7, 1875	28.8	Mar. 30, 31	27.0	— 1.8	Nov. 7-23, 1896	— .2	Sept. 4, 5	1.8	+1.8
White	Jacksonport, Ark	Mouth	360		Mar. 14, 1890	33.35	Mar. 30	32.50	— .85	Dec. 24, 1872	— 1.10	Jan. 10	2.15	
Do	Clarendon, Ark	do	134	158.9	Mar. 20, 1890	26.63	Apr. 5	25.4	— 1.23	Nov. 22, 1887	4.07	Sept. 11, 12	2.20	+3.30
Yazoo	Yazoo City, Miss	do	65	93.84	1882	26.50	Apr. 26-28	24.4	—12.10	1875	— 4.30	Sept. 12	9.85	+5.28
												Nov. 9, 10	—1.0	+3.80

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TABLE NO. 8.—*Maximum readings of flood of 1899 on high-water and regular gauges, Mississippi River, Cairo, Ill., to Fort Jackson, La.; also those of 1897 for comparison.*

[NOTE.—All gauges were read at or near the flood stage. Some were read before the crest was reached; these are indicated by * in elevation column. In such cases the reading given is obtained by interpolating the value of the rise after the first readings were made. The correction was in each case deduced from the nearest regular gauge. Where gauge numbers and readings are omitted, no reports have yet been received.]

Name of gauge.	Distance from Cairo.	Date of highest reading, 1899.	Regular gauge readings.	Maximum elevation above Memphis datum.		Differences compared with 1897.
				Flood of 1899.	Flood of 1897.	
	Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	0.0	Apr. 2	46.24	323.95	329.4	—5.45
179	17.8	Apr. —		317.3	321.4	—4.1
Belmont	21.3	Apr. 4	42.0	315.72	318.7	—2.98
177	35.5			311.4	314.2	—2.8
175	44.3	Mar. 29–31, Apr. 1		307.1	309.7	—2.6
174	49.8	Mar. 22		305.2	308.0	—2.8
New Madrid	70.3	Mar. 30	36.10	298.69	302.9	—4.21
170	78.3	Apr. 6		296.3	300.8	—4.5
168	84.8	Mar. 31–Apr. 3		292.4	296.3	—3.9
165	99.3	Apr. 2		284.4	288.0	—3.6
163	109.3			279.3	283.3	—4.0
161	118.5	Apr. 5–7		275.4	278.8	—3.4
Cottonwood Point	123.0	Mar. 30–Apr. 3–4, 7–8	36.45	273.99	276.8	—2.81
158	135.0	Apr. 2–8		269.3	273.0	—3.7
153	161.8	Mar. 29		256.6	260.2	—3.6
152	167.5	Apr. 1, 3–4		254.2	258.3	—4.1
Fulton	175.4	Apr. 7	34.9	250.32	252.9	—2.58
150	180.1	Mar. 31		248.2	251.2	—3.0
149	186.3	Apr. 10		245.2	247.5	—2.3
148	192.3	Mar. 30–Apr. 1		243.0	245.7	—2.7
147	197.3	Mar. 29, Apr. 8		241.2	243.8	—2.6
145	208.0			236.45	238.4	—2.0
142	225.5	Apr. 2		227.7	229.3	—1.6
Memphis	230.0	Apr. 1–11	35.20	226.04	228.5	—2.46
141	235.0	Mar. 25		223.2	225.1	—1.9
140	239.5	Apr. 5–6		221.7	222.9	—1.2
138	249.5			220.7	218.2	—2.5
137	256.3			218.20	215.4	—2.2
136	261.3	Apr. 7–12		211.2	213.6	—2.4
135	266.8	Apr. 6–8		209.1	211.8	—2.7
134	271.0			†209.0	210.8	—1.8
Hilboon Landing	277.3	Apr. 7–14	38.0	206.35	210.0	—3.65
133	280.5			†207.3	209.5	—2.2
131	289.5	Apr. 10–14		201.2	206.6	—5.4
130	293.5	Apr. 13		202.0	205.0	—3.0
129	297.8			198.9	204.6	—5.7
128	301.5			197.9	203.2	—5.3
Helena	306.5	Apr. 12–15	46.75	195.6	200.6	—5.0
126	317.8			191.5	195.2	—3.7
125	323.5			189.4	193.2	—3.8
124	329.3			187.3	190.9	—3.6
123	334.5	Apr. 10–14		186.1	189.4	—3.3
122	339.0			183.4	185.8	—2.4
121	342.5	Apr. 3		181.5	184.8	—3.3
120	346.8	Apr. 20		181.0	183.1	—2.1
Sunflower Landing	352.7	Apr. 12–16	44.3	178.25	181.1	—2.85
118	362.0	Apr. 11–12		175.5	178.5	—3.0
117	366.8	Apr. 10–16		173.6	176.5	—2.9
116	371.8			172.2	175.1	—2.9
115	378.0	Apr. 16		169.1	172.5	—3.4
114	383.5	Apr. 14–16		167.3	170.4	—3.1
Mouth of White River	393.2	Apr. 15–16	48.49	164.09	168.0	—3.91
112	398.5	Apr. 15		162.4	166.2	—3.8
111	401.8	Apr. —		161.5	165.3	—3.8
110	408.0	....do		160.3	164.0	—3.7
109	412.0	Apr. 19		159.0	162.9	—3.9
108	416.8	Apr. 12		158.28	162.4	—4.12
107	421.5	Apr. 15–17		156.5	160.6	—4.1
106	427.0	Apr. 16–17		155.6	159.7	—4.1
105	432.5	Apr. 15–19		153.3	157.0	—3.7
Arkansas City	438.3	Apr. 15–20	48.6	151.91	155.2	—3.29
104	444.8	Apr. —		149.2	152.4	—3.2
103	449.5	Apr. 17–20		148.2	151.6	—3.4
102	456.5	....do		146.6	148.6	—2.0
101	459.0			144.5	148.2	—3.7
100	463.5	Apr. 17–20		144.0	147.3	—3.3
99	467.0	Apr. 15–19		143.2	147.0	—3.8
98	473.3			140.7	144.0	—3.3
Greenville	478.3	Apr. 17–20	43.0	137.87	141.6	—3.73
97	482.5	Apr. —		*137.3	140.5	—3.2
96	487.0	Apr. 18–19		136.4	139.7	—3.3
95	489.8	Apr. 18		135.3	138.6	—3.3
94	495.3	Apr. 18–20		133.4	136.9	—3.5

*Correction, +1.0.

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TABLE No. 8.—*Maximum readings of flood of 1899 on high-water, etc.*—Continued.

Name of gauge.	Distance from Cairo.	Date of highest reading, 1899.	Regular gauge readings.	Maximum elevation above Memphis datum.		Differences compared with 1897.
				Flood of 1899.	Flood of 1897.	
	Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
93	501.0	Apr. 18-20	.....	130.9	134.8	—3.9
92	505.5	Apr. 17-20	.....	130.0	133.8	—3.8
91	510.5	Apr. 18	.....	127.7	131.2	—3.5
91A	510.8	.....do	.....	127.6	.....	.....
90A	517.0	Apr. 17-18	.....	125.9	.....	.....
90	517.0	Apr. 16-21	.....	125.9	129.0	—3.1
89	522.5	Apr. 21-22	.....	124.0	127.6	—3.6
88	525.8	.....	.....	122.7	125.8	—3.1
87	531.5	Apr. 18	.....	121.15	123.8	—2.6
86	537.5	.....do	.....	119.5	122.3	—2.8
Lake Providence	542.3	Apr. 16-21	41.65	118.14	121.0	—2.86
85	546.5	Apr. 17-18	.....	117.65	119.9	—2.25
84	552.3	.....do	.....	115.5	117.9	—2.4
83	556.5	Apr. 18	.....	113.77	116.4	—2.63
82	561.3	Apr. 20	.....	112.55	115.4	—2.8
81	568.0	.....do	.....	109.00	112.2	—3.2
80	573.5	Apr. 21	.....	107.43	110.9	—3.5
79	578.0	Apr. 20	.....	106.25	109.8	—3.55
78	583.5	.....do	.....	105.3	109.2	—3.9
77	588.5	.....do	.....	103.20	108.0	—4.8
76	593.5	Apr. 19-22	.....	101.9	107.0	—5.1
Vicksburg	599.3	Apr. 17-23	47.30	100.21	105.4	—5.19
75	602.8	Apr. 18	.....	99.0	103.2	—4.2
74	607.5	Apr. 18-22	.....	98.4	102.6	—4.2
73	612.5	Apr. 18	.....	95.6	99.7	—4.1
71	622.0	Apr. 18-22	.....	91.5	96.5	—5.0
69	633.0	Apr. 22	.....	87.1	92.4	—5.3
67	642.8	Apr. 19-22	.....	84.2	88.7	—4.5
St. Joseph	648.3	Apr. 21-24	43.25	82.86	87.5	—4.64
66	655.3	Apr. 24	.....	80.00	84.4	—4.4
64	663.8	.....do	.....	.....	82.6	.....
63	680.8	Apr. 15	.....	76.8	81.6	—5.5
62	685.5	Apr. 23	.....	75.43	79.9	—4.47
62A	687.5	Apr. 22-23	.....	75.05	.....	.....
60	694.0	Apr. 21-25	.....	72.1	76.2	—4.1
Natchez	700.3	Apr. 23-25	46.15	69.91	73.6	—3.69
58	711.3	Apr. 21	.....	67.6	71.5	—3.9
57	716.0	Apr. 23	.....	66.9	70.8	—3.9
56	720.5	Apr. 20-22	.....	65.4	69.3	—3.9
54	731.0	Apr.—	.....	a 61.7	66.3	—4.6
50	751.5	Apr. 22	.....	56.9	63.2	—6.3
49	756.0	Apr. 23-26	.....	55.4	62.3	—6.9
Red River Landing	765.3	Apr. 22-27	43.30	54.02	60.9	—6.88
47	769.0	Apr. 22	.....	53.9	60.0	—6.1
44	784.8	Apr. 21, 23	.....	50.4	57.5	—7.1
42	794.5	Apr. 24-25	.....	47.9	55.5	—7.6
Bayou Sara	799.8	Apr. 21-26	36.7	47.52	54.6	—7.08
41	803.5	Apr. 20-21	.....	46.2	53.3	—7.1
40	808.0	Apr. 19-20	.....	45.7	53.2	—7.5
38	817.0	Apr. 21-22, 25-27	.....	44.5	50.6	—6.1
Baton Rouge	833.3	Apr. 21-28	33.7	40.63	47.6	—6.97
33	850.0	Apr. 16-20	.....	38.0	44.5	—6.5
Plaquemine	854.1	Apr. 21, 25	30.1	38.03	44.2	—6.17
32	859.8	Apr. 21	.....	37.0	43.0	—6.0
Donaldsonville	885.4	.....do	27.50	33.845	39.1	—5.255
27	889.8	.....do	.....	33.55	38.9	—5.35
25	900.3	.....do	.....	31.7	36.7	—5.0
College Point	904.5	.....do	23.15	31.26	36.1	—4.84
24	910.5	Apr. 20	.....	30.1	34.7	—4.6
22	919.8	Apr. 21-22	.....	28.8	33.1	—4.3
21	925.5	Apr. 21	.....	28.2	32.0	—3.8
19	934.3	.....do	.....	26.2	30.2	—4.0
17	943.5	Apr. 22	.....	25.22	28.9	—3.68
15	953.0	Apr. 21	.....	24.3	27.2	—2.9
Carrollton	957.0	.....do	16.0	23.78	26.95	—3.17
14	968.0	.....do	.....	21.8	24.0	—2.2
13	973.5	Apr. 20-22, 24, 25	.....	21.0	23.3	—2.3
11	983.5	Apr. 21	.....	19.4	21.0	—1.6
10	989.3	.....do	.....	18.8	20.4	—1.6
9	993.0	.....	.....	.....	19.4	.....
8	999.0	.....	.....	.....	19.1	.....
7	1,008.8	Apr. 21	.....	16.8	18.1	—1.3
5	1,013.0	.....do	.....	16.5	16.9	—0.4
4	1,019.0	Apr. 20-21	.....	15.1	15.9	—0.8
3	1,023.8	Apr. 18-21	.....	14.7	15.5	—0.8
2	1,029.0	Apr. 19-20	.....	14.2	14.8	—0.6
Fort Jackson	1,039.0	Apr. 21	6.975	13.105	13.3	—0.195

a Correction, +0.45.

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Highest gauge readings, tributaries, 1899 (to May 23, 1899).

Station.	River.	Date.	Gauge reading, 1899.	Prior to 1899.	
				Gauge reading.	Year.
			Feet.	*Feet.*	
St. Louis	Mississippi	Apr. 27	25.60	35.95	1892
Little Rock	Arkansas	May 11	25.90	31.20	1892
Barbre Landing	Atchafalaya	Apr. 25–28	41.60	50.95	1897
Nashville	Cumberland	Feb. 11	40.60	55.30	1882
Cincinnati	Ohio	Mar. 8	57.2	71.06	1884
Louisville (Upper)	do	Mar. 10	32.80	46.60	1884
Louisville (Lower)	do	do	58.30	72.00	1884
Paducah	do	Apr 4–5	43.8	54.25	1884
Camden	Ouachita	Jan. 17–18	39.10	46.0	1882
Fulton, Ark	Red	Jan. 17	22.55	35.75	1876
Garland	do	do	24.10	28.50	1894
Shreveport	do	Jan. 24	15.60	35.70	1892
Alexandria	do	Jan. 27	18.20	38.25	1892
St. L., I. M. & S. Ry. Bridge	St. Francis	Apr. 11–15	30.3	41.6	1897
Chattanooga	Tennessee	Mar. 22	40.0	54.0	1875
Florence	do	Mar. 20	25.20	32.20	1897
Jacksonport	White	May 13	28.90	33.35	1890
Clarendon	do	Jan. 24–25	28.90	36.63	1890

TABLE NO. 9.—*Mean readings of Biloxi self-registering tide gauge referred to zero of staff gauge.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1881							
1882	5.912	5.919	6.084	6.234	6.247	6.236	6.169
1883	5.485						
1884		5.684	5.936	6.066	6.100	6.226	5.723
1885	5.676	5.698	5.598	6.026	6.055	6.053	
1895							
1896	5.529	5.590	5.629	6.061	6.274	6.360	6.239
1897	5.769	5.835	6.107	6.226	6.039	5.983	6.263
1898	5.722	5.788	6.036	5.582	5.876	6.106	6.354
1899	5.756	5.787	5.868				
Means *a*	5.7216	5.7632	5.9584	6.0338	6.1072	6.1822	6.1496
Means *b*	5.6927	5.7501	5.8940	6.0325	6.0985	6.1607	6.1496

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual means.	Grand means.
1881		6.492	6.716	6.108	5.835		
1882	6.276	6.565	6.561	5.881	5.560	6.1370	
1883							
1884	6.039	6.645	6.591	5.849	5.905	*c* 6.0367	
1885							
1895		6.492	5.946	5.634			
1896	5.975	6.456	6.321	6.470	5.905	6.0674	
1897	5.958	6.476	6.530	6.146	5.886	6.1015	
1898	6.423	6.815	6.295	6.234	5.633	6.0720	
1899							
Means *a*	6.1342	6.5914	6.4596	6.1160	5.7778		6.0829
Means *b*	6.1342	6.5748	6.5009	6.0984	5.7674		6.0712

a Derived from the monthly means for the years 1882, 1884, 1896, 1897, and 1898, and the monthly mean for January, 1885.

b Derived from all records given above.

c Record for January, 1885, was used in computing annual mean for 1884.

NOTE.—Final value of mean Gulf level, derived as above, is 6.0829 feet, with a probable error, computed from the yearly means, of ± 0.0114 foot.

BILOXI STAFF GAUGE AND BENCH MARKS.

Standard staff gauge of Biloxi tidal observations is nailed to piling at northwest end of drawspan, when open, of railroad bridge over Biloxi Bay. The staff is graduated in feet and tenths from zero to 12 feet and reads by means of a micrometer attachment to hundredths of a foot. This staff was set in October, 1895.

The final value of mean Gulf level reads on this gauge 6.0829 feet.

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BENCH MARKS.

P. B. M. 19 (U. S. Coast and Geodetic Survey H_1) is 225 meters west of the west end of Biloxi Bay Bridge. It is 30 meters south of the center of track of the Louisville and Nashville Railroad. The B. M. is a cross cut on the top of the marking stone, set in the ground. The top of the stone has been splintered off in places and the copper bolt is gone. Pine trees near the stone are marked with five narrow blazes.

Elevation above zero of gauge, 11.939 feet.

P. B. M. 19 A is on top of stone monument upon which P. B. M. 19 was established. The B. M. is a cross cut on corner of stone nearest the bay.

Elevation above the zero of gauge, 11.770 feet.

Coast and Geodetic Survey P. B. M., E_1, is near the east end of Biloxi Bay Bridge and about 68 meters south of the Louisville and Nashville Railroad track, in the yard of, and near the northwest corner of the frame house owned and occupied by, the Rev. J. B. Walker. The B. M. is the bottom of the square cavity cut in the top of the marble stone marking the point. The stone is 6 by 4 inches on top, projecting about 1 inch above ground, and has the letters U. S. C. S. cut upon the top. Distance from center of bench to brick pier under northwest corner of house, 0.8 mile.

Elevation above zero of gauge, 21.803 feet.

B. M. "A," is top of iron strap on floor (at level of floor of cable house) at west end of drawspan of Biloxi Bay railroad bridge. B. M. is marked by letter A cut in strap and is at apex of the letter. It is 26 inches northwest from northwest corner of base of the northwest end strut of the drawspan, when closed, and is 32 inches east of door of cable house. It is on the east end of top of strap. The strap is 2 inches wide and the top surface is 16 inches long.

Elevation above zero of gauge, 12.050 feet.

B. M. "B," is upper edge of iron plate at angle in the line of piling near gauge house. Marks are cut thus ⩚ in the iron, and the letter B is cut in plank near the B. M.

Elevation above zero of gauge, 11.657 feet.

B. M. "C," is upper edge of iron plate encasing concrete of center pier of drawspan of the Biloxi Bay Bridge (on Louisville and Nashville Railroad). It is at the extreme north end and is marked by a cold chisel cut. A mark thus (U C S) is cut in concrete.

Elevation above zero of gauge, 7.144 feet.

APPENDIX 1 G.

REPORT OF MR. THOMAS MIDDLETON, ASSISTANT ENGINEER, ON REPAIRS TO PLANT AND CONSTRUCTION OF NEW PLANT.

ST. LOUIS, MO., *May 31, 1899.*

CAPTAIN: I have the honor to submit my annual report upon the work of this department, which consists of designing new plant, the preparation of drawings and specifications for same, the determination and designing of repairs to dredging plant, and the supervision of the construction of new and repairs to existing plant.

Dredge Alpha.—The record of this dredge for the last dredging season was not a very encouraging one. Shortly after going into the field the pump runner became loose, and the spare shaft and runner had to be put in. Later on the engine gave considerable trouble from hot bearings, and a critical examination showed that the last crank had twisted slightly on its pin, and consequently one part of the shaft was not in line or running truly with the other parts. This shaft is of the built-up type, and constant hard work and possibly expansion from heated crank pins had allowed the last crank, through which all the work was passing, to give way. The shaft was taken apart, a new crank pin made, the cranks pressed on again and the shaft carefully trued up in all its bearings. Subsequently the dredge was operated without further trouble, but owing to the comparatively high stage of the river she was withdrawn from service and laid up in winter quarters at the end of October. It is now nearly six years since this boat, which has a wooden hull, was launched, and the seams have become so soft that it will be necessary to haul her out of the water at the earliest opportunity to have her overhauled and recalked.

Dredge Beta.—At the close of June, 1898, this dredge was in the Government dry dock at Keokuk, Iowa, undergoing alterations with the obect of reducing the draft to 4 feet, improving the machinery, and providing the requisite cabin accommodations to enable her to care for her own crew.

The contractors for altering the hull by the addition of side extensions and the remodeling of the bow and stern, were behindhand in the completion of their work,

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and it was not until September 16 that the *Beta* was ready to be taken out of dock. In the meantime a large amount of work had been done by hired labor, including the installing of the two 16-inch pressure pumps for jet agitation, electric-light engine and generator, and three steam capstans; the removal of the filters from after hold to forward of main engines; the changing of feed and filter pumps to more convenient locations; the remodeling of the pipe system incident to changes of machinery; the alteration of deck houses, etc. Much of the work of alteration had to be delayed until the dredge arrived at St. Louis, owing to the necessity for keeping the draft as light as possible on account of low water. After meeting with considerable difficulty from this cause, the *Beta* arrived at St. Louis October 14; the balance of the work was at once undertaken. This consisted of erecting steam winches and spud lifting cylinder, pipe fitting, plumbing, electric lighting, the building of cabins, etc., together with the contractors' unfinished work on hull and discharge mains from pumps. The *Beta* was practically completed by December 25, 1898, and was sent to winter quarters with the fleet at Memphis, to await a favorable opportunity for undergoing a test before taking the field next season.

Dredge Gamma.—The records show that the interruptions which occurred while dredging arose from minor causes, namely: the clogging of injection and feed pipes, the loosening of valve seats in air pump, and the breaking of a collar on valve stem of air pump. The low pressure piston head of jet pump also broke, but the dredging was continued without the jet agitator until the repair was completed. The main pumping machinery appears to have worked satisfactorily, but it was evident toward the close of the season that the efficiency of the pump was materially reduced.

Dredge Delta.—The record of the *Delta* for the dredging season of 1898 indorses the opinion already formed and expressed by me in my last annual report, namely, that a mechanical agitator of this design was not suitable for the snaggy condition of the Mississippi River and would always be a source of interruption and delay to continuous dredging. An examination of the daily reports shows that the stoppages arising from breakages to the agitator amounted to 34 per cent of the total dredging time, while the stoppages from all other sources, including packing of main engine, the parting of pipe-line connections, the breaking of hauling cables, etc., were only about 11 per cent. The continued trouble experienced by the parting and loss of the driving chain of agitator forced the conclusion that it would be necessary to abandon the open-link type and adopt a pin-connected chain in its place. Designs were accordingly prepared for chains with cast-steel links, hard-steel pins, and bushes. The agitator is also undergoing some alterations and substantial repairs, which will reduce the stoppages to those incident to the picking up of snags and clogging with drift. In other respects the dredge compares most favorably with any in the fleet.

Dredge Epsilon.—So far as the actual field work is concerned, this dredge shows an excellent record, the delays from all causes being less than 8 per cent of the total dredging time. These delays arose partly from the breaking of head cables, the parting of pipe line at rubber connections, and the adjusting of engine governor, and partly from hot slides on main engine. During the season, however, a break in one side of the pump casing was developed, and examination showed that the metal, which was originally 1¼ inches thick, had worn completely through. The pump was repaired temporarily during a period of high water, and fortunately did not interfere with dredging operations. This matter is considered later on in this report.

Dredge Zeta.—The *Zeta* went into the field with the mechanical agitator ready for operation, but as the efficiency tests had demonstrated its unreliability, the dredge had been fitted with a water-jet agitator, centrifugal pump, and engine similar to those on the sister dredge *Epsilon*.

The old trouble was experienced in keeping the agitator to its work, and practically it remained idle the greater part of the time while the water jet was used. As this device was a very inefficient means of loosening the material to be dredged, and its use involved much delay in attempting to keep it in working order, the engine and machinery were removed while the *Zeta* was waiting for a lower stage of water. With this exception the performance of this dredge was very similar to that of the *Epsilon*, the delays in actual dredging time arising principally from causes outside of the dredging machinery proper, such as the separating of pipe line at rubber connections, breaking head cable, clearing out suction head, etc.

Dredging pumps.—It was a matter of surprise to find that the pump casing of the *Epsilon* had actually worn through a thickness of 1¼ inches of metal before the expiration of her first season's work, and after the dredges were all in winter quarters the pumps were taken apart and a careful examination of their interior condition was made. The makers of the double suction pumps on the *Gamma*, *Epsilon*, and *Zeta* evidently expected the wearing action of the sand to be most severe on the periphery of casing and the lip of the discharge entrance; extra thickness of metal was put at these places to provide for this anticipated need. A form of pump was adopted which made it impracticable at any reasonable cost to fit the casings with

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renewable liners where it was supposed such provision would be required, and hence the expedient of extra metal was resorted to instead. In the case of the *Gamma* this amounted to a thickness of 2½ inches, and in the other two dredges from 2 inches to 3½ inches. An examination of these three pumps showed, however, that the greatest wear had taken place at the throat or entrance of the suction, then alongside the blades of runner, diminishing toward their points. In the pumps of the *Epsilon* and *Zeta* this wear was excessive at the immediate turn into the casing, which is of a rather small radius; in the *Gamma's* pump the wear was less in depth, but extended farther into the pump casing, and was in grooves of varying depth, which formed a series of waves in cross section. The edges of the blades had also worn considerably, until the actual clearance between blades and casings was over 2 inches in some places; this accounts for the falling off of the pump efficiency during the season.

Referring now to the pump of dredge *Delta*—this pump is of the single-suction type, has a casing of rectangular section, and is fitted with liners throughout. At the end of two seasons of dredging the liners were worn to about one-half their original thickness, which was five-eighths of an inch, and the clearance at edges of runner blades was not sufficient to reduce the pump efficiency below the limits of profitable dredging.

In considering these worn pump casings, it is evident that the incoming material receives a violent rotary motion from the runner blades, the influence of which extends a considerable distance into the suction elbows. The abrading action is to be measured by the centrifugal force with which the material is pressed against the retaining surfaces. As this centrifugal force is proportionate to the velocity, it follows that the ratio of wear in the different pumps can be measured by the relative velocities of the runners, leaving out of consideration any difference there might be in the mass of solid material passing into the several pumps, the difference of the abrading qualities of the various sands met with in dredging, the relative distances that the heels of runner blades extend into the suction mouth, and the form of suction mouth, all of which have some influence on the amount of wear.

In speaking of velocities in this case the number of revolutions is under consideration, and not the peripheral velocity of the runner, which is a factor of the pump's performance, but has nothing to do with the wear that is taking place at or near the hub. Looking, then, at the number of revolutions at which the pumps are run, this will be found to correspond with tolerable accuracy to the amount of wear which has actually taken place, namely: *Delta*, 140 revolutions; *Gamma*, 150 revolutions; *Zeta*, 180 revolutions, and *Epsilon*, 180 revolutions. The increased wear shown by the *Epsilon* as against the *Zeta* is easily accounted for by the greater number of hours the former has actually dredged.

The conclusions arrived at from past experience may be briefly stated as follows:

1. A method of compensating for wear by means of renewable liners is absolutely necessary.

2. A method of preventing the rotary action of the material from extending into the suction elbows is desirable.

3. The number of revolutions of the pump runner should be limited to an average of from 140 to 150 per minute.

4. A method of reducing or compensating the wear between edges of runner blades and casing should be adopted.

A pump has been designed in which the above requirements have been fully adopted and is shown on accompanying plate. This pump is fitted with renewable liners throughout; the inflowing material is prevented from taking a rotary motion in the suction elbows by baffle plates; the point at which the wear due to this rotary motion is most severe is protected by a heavy renewable liner, which is held in place between the suction elbows and casing, thus dispensing with bolts or other fastenings; the wear on edges of runner blades is entirely obviated by making an inclosed runner—that is, side plates are riveted to the edges of blades and prevent the sand, etc., from grinding between blades and casing; the slight wear which will take place on outside of runner will not reduce the efficiency of the pump; by adopting the double-suction type of pump the difficulty of balancing the suction force is eliminated and thrust bearings on collars are unnecessary. It is anticipated that this design of pump will prove both more efficient and less costly to maintain than any at present in use, and will ultimately become the standard for the dredging fleet.

In this connection I may say that means have been taken to remedy the defects of the pumps of the *Gamma*, *Epsilon*, and *Zeta*, as far as practicable, by fitting them with renewable liners in the parts most exposed to wear.

WORK UNDER CONSTRUCTION.

Large tenders.—The Iowa Iron Works, Limited, Dubuque, Iowa, are building five large steam tenders according to the plans and specifications which appeared in the

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last annual report. This work has not progressed as rapidly as was expected, and one hull only has been launched up to the present time. All the engines, however, are well advanced, and the boilers and minor parts will be ready and waiting for the hulls. The joiner work is well in hand and will keep pace with the other parts. So far the work in general is of excellent character.

Small tenders.—The three small tenders built under contract with the M. A. Sweeney Company, Jeffersonville, Ind., have just been delivered. This class of boat, of which the *Vulcan* was the leader, has been found to be of very great service in the fleet, being small enough to be easily handled, large enough to move a coal barge or even a dredge in slack water in case of emergency, and quick enough for ordinary use as general tender and dispatch boat.

Dredge Iota.—The contract for this, the first of the self-propelling type of dredges, was awarded to the Springfield Boiler and Manufacturing Company, of Springfield, Ill. At this writing the hull is not yet completed, and the work in general on the machinery and other accessories is not very far advanced, but the contractors fully expect to have the dredge ready for the coming season's operations.

Repairs to plant.—Outside of the usual general repairs to the fleet, the year's work in this direction has been the installation of the new boilers and completion of repairs to steamer *Minnetonka*, which were in hand at the close of the last fiscal year, and the fitting of liners to pumps of dredges *Gamma*, *Epsilon*, and *Zeta*. In the case of the former dredge heavy cast-iron liners are bolted directly to the worn parts of casing and the runner trimmed down as required to suit the decreased width. In the case of the *Epsilon* and *Zeta*, however, the pump casings were reduced so much in thickness at the throat that it was necessary to cut out the center parts entirely and insert false centers or rings between the suction elbows and the main part of casing. These rings are prepared to take renewable wearing pieces of considerable thickness at the point where abrasion from the sand is greatest; and beyond this point on the flat sides of casing where the abrasion is less, steel plates five-eighths inch thick are fitted. A special boring tool was prepared for this purpose and the work done without removing the pumps from their places.

Office work.—During the year a number of detail drawings and erection plans were made for dredge *Iota;* a set of 17 drawings and specifications for new dredges, and sundry drawings required for alterations and repairs to dredge *Beta* and the fleet. The usual supervision and inspection of all work under construction, both contract and repair, has been maintained.

THOMAS MIDDLETON,
Assistant Engineer.

Capt. MASON M. PATRICK,
Corps of Engineers, U. S. A., Secretary Mississippi River Commission.

APPENDIX 1 H.

REPORT OF MR. F. B. MALTBY, ASSISTANT ENGINEER, ON DREDGING OPERATIONS ON THE MISSISSIPPI RIVER BETWEEN CAIRO, ILL., AND HEAD OF THE PASSES, LOUISIANA.

UNITED STATES DREDGE FLEET,
West Memphis, Ark., May 15, 1899.

CAPTAIN: I have the honor to submit the following report of operations of the dredge fleet belonging to the Mississippi River Commission for the year ending May 15, 1899:

At the beginning of the year the dredge fleet was under the direction of Mr. C. W. Sturtevant, assistant engineer, who had been connected with dredging operations as superintendent since the inauguration of the project of improving the channel of the river by means of hydraulic dredges by the commission. I relieved him on July 27, 1898, he having been commissioned captain in the Third Regiment of Engineers.

CARE OF PLANT.

At the beginning of the year the fleet was laid up in ordinary at New Madrid, Mo. It consisted of the dredges *Alpha*, *Gamma*, *Delta*, *Epsilon*, and *Zeta;* the steamers *Search*, *Vidalia*, and *Vulcan;* 4 pile sinkers, Nos. 33, 21, 61, and 971; 1 measuring barge; 1 quarter boat, No. 13; 2 small sunk-deck fuel flats; 9 framed and flush-decked barges, and 1 calking flat. The dredge *Beta* and machine shop on barge 153 were at Keokuk, Iowa, where the dredge was being remodeled. The steamer *Minnetonka*, which belonged to the dredge fleet, was at St. Louis undergoing extensive repairs.

During the month of August, 1898, pile sinkers Nos. 981, 982, 983, 984 were received from Cincinnati, where they had been built under contract.

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The steamer *Patrol*, belonging to the allotment for surveys, gauges, and observations, was cared for till November 5, 1898, when she was turned over to E. L. Harman, surveyor.

During the interval from the beginning of the year to the beginning of the dredging season the plant was cared for in the usual manner and the following repairs made:

The cabins of the dredges *Alpha*, *Gamma*, *Delta*, *Epsilon*, and *Zeta* and steamer *Search* were painted, both inside and out, by contract.

Dredge Alpha.—Only minor repairs to main engines, steam piping, and winding engines were made.

Dredge Gamma.—Main pump and engines were thoroughly overhauled, liners placed in shell of the pump over the throat, crank disk bored out and new pin made for high-pressure engine, minor repairs made to jet engines and boiler pumps, all outside ironwork above the water scraped and painted by hired labor.

Dredge Delta.—Only minor repairs made to main engine and pump and hoisting machinery; outside ironwork above water line scraped and painted by hired labor.

Dredge Epsilon.—Minor changes made to steam piping and hoisting tackle for suction head; lockers built in staterooms; roof painted.

Dredge Zeta.—A new jet pump and engine, with connections similar to the one on the *Epsilon*, was erected in place; minor changes made in steam piping and hoisting tackle for suction head.

Pile sinkers.—The machinery for pile sinkers Nos. 981, 982, 983 was erected in place, cabins built and painted. The cabin was built on No. 984, but machinery was not placed in position, as the pile sinker was not required during the season. Minor repairs to machinery of pile sinkers Nos. 21 and 61 were made.

Four flush-deck framed barges, used for plunder barges, were calked above the water line.

At the close of the dredging season of 1898 the dredge fleet was taken to the vicinity of West Memphis, Ark., where it has been cared for in the usual manner. A small force has been retained and has been employed in making repairs and changes to the plant, as follows:

Dredge Alpha.—Only minor repairs to feed pumps and electric-light engine have been made.

Dredge Beta.—This dredge arrived at the West Memphis fleet December 31, 1898. Very little work has been done on her toward completing the extensive changes made during 1898. Machinery has been erected in machine shop, steam pipes partly covered, a small amount of carpenter work done on her cabins, and the new woodwork of cabins given one coat of paint.

Dredge Gamma.—Slide valves on high-pressure cylinders of main and jet engines have been faced up and seats scraped down. The main pump has been torn down and throat castings bored out to receive new liners, which have been made by the Memphis Machine Works. Auxiliary machinery, pumps, etc., have been overhauled, valves ground, etc.

Dredge Delta.—Extensive alterations of cabin arrangements on this dredge have been made and are nearly completed. A large filter originally intended for filtering water supply for boilers was bursted in the spring of 1898 and has been cut up and removed. Changes in pipe work made necessary by alterations in cabin and removal of filter have been nearly completed. New liners have been placed in main pump casing, and a new babbitted bearing for main shaft at pump made. Drawings for a new sprocket chain for the agitating machinery have been made, and some small changes made in the arrangement of this machinery.

Dredge Epsilon.—The entire interior of the hull has been scraped, and painted with red lead and oil. The main pump was taken down and examined and drawings showing the wear of the casing made. Owing to the excessive amount of this wear, extensive repairs to the casing were found necessary and the work, to be done by the force on the fleet, is well under way. The discharge openings from the bilge siphons have been raised to prevent entrance of water from the river. They formerly discharged only a few inches above the water surface. Auxiliary pumps have been overhauled and valves ground.

Dredge Zeta.—About one-half the interior of the hull has been scraped and painted, discharge openings from bilge siphons have been raised, auxiliary pumps have been overhauled, steam-heating arrangements for cabin have been erected, and stoves discarded. An examination of main pump showed the same excessive wear as noted on the *Epsilon*, and the same extensive repairs are being made. A large boring bar, for boring out casing, has been made and erected in position, and boring partly completed. The same apparatus will be used on the *Epsilon*.

Pile Sinker No. 984.—The machinery has all been erected and connected up.

Steamer Search.—A large amount of material necessary for extensive repairs to hull has been received. It is the intention to beach this boat and, on the subsidence of the water, block her up and make the needed repairs by hired labor. She will afterwards be pulled into the water on ship ways.

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Steamer Mississippi.—This boat was turned into the fleet on December 31 to be cared for. New stacks were purchased in Memphis and were erected by hired labor. Furnace walls have been rebuilt, new siphons placed in each of the thirteen compartments of the hull, machinery overhauled, and the searchlight from the *Minnetonka* placed on her.

Steamer Patrol.—This boat, belonging to the allotment for surveys, gauges, and observations, was turned into the fleet March 2, 1899. A new ice box has been built, roof painted, machinery thoroughly overhauled, and new furnace walls built.

DREDGING OPERATIONS.

The project for the dredging season of 1898 contemplated dividing the river below Cairo into three districts, as follows: First, from Cairo to and including Hathaways Crossing; second, from Hathaways Crossing to the head of Island No. 40; and third, from the head of Island No. 40 as far down the river as dredging should become necessary. A survey party was placed in each one of these districts. These parties made a preliminary survey of all bars that it was thought might require dredging; also made surveys immediately before dredging at each bar for the purpose of properly locating the dredge cut; also surveys during dredging, and on the completion of the same, to show the effect of the dredging. The surveyor in charge also located the dredge in the absence of the superintendent. C. M. Talbert, surveyor, was in charge of the first district; E. L. Harman, and afterwards M. I. Powers, surveyors, were in charge of the second district, and W. G. Comber, assistant engineer, in charge of the third district. The general supervision of the entire fleet and the survey parties was under the superintendent of dredging. He was furnished a suitable steamer used as an inspection boat, and from September 1 to the end of the dredging season was engaged constantly in passing over the river, inspecting and directing the work of the dredges and survey parties, sounding all crossings, and keeping fully informed of the condition of the river and location of best channels.

Frequent reports were made to the pilots' associations concerning the river channel; buoys were set marking the channel in difficult places, and, by permission of the officers in charge of the local light-house district, the positions of the lights were changed to agree with new channels as they developed. In fact, it was the intention of the superintendent to furnish all the information possible to the steamboat interests and make the dredging operations of as much value as possible. The steamer *Mississippi* was used as an inspection boat from September 1 to November 5, the *Minnetonka* from November 5 to 7, the *Fred Hartweg* from November 7 to December 10, and the *Search* from December 10 to 22, the close of the season.

The organization of each dredging party, consisting of a double crew, was as follows: One master, 2 mates, 2 engineers, 2 operators, 1 recorder, and 1 steward, with the necessary number of linesmen, firemen, laborers, cooks, and waiters, from 48 to 52, all told. This does not include the crew of the tender. The equipment of a dredging party consisted of the dredge proper; 1 pile sinker; 1 plunder barge for carrying spare piles, machinery, and supplies of various kinds; 1 fuel barge, and a towboat or tender for moving the outfit from place to place. The tender carried only a single crew of from 12 to 16 men.

The following steamers were chartered as tenders during the season: The *Defender* from September 8 to November 1, 1898, both dates inclusive, at $60 per day; the *H. F. Frisbie* from August 31 to December 9, 1898, both dates inclusive, at $48 per day; the *Tom Rees No. 8* from August 31 to November 21, 1898, both dates inclusive, at $48.75 per day; the *Beaver* from August 31 to November 21, 1898, both dates inclusive, at $45 per day, and the *Fred Hartweg* from August 31 to December 26, 1898, both dates inclusive, at $40 per day. The charter price paid was for the use of the steamer and equipment only, and does not include cost of operation.

The operations of each dredge in detail are given below:

Dredge Alpha.—This dredge left New Madrid September 10, 1898, and arrived at Peters Towhead on the 13th. The project for work in this vicinity was to attempt to fill the channel across the head of Peters Towhead and thus cause more water to flow down the channel to the left. This attempt was only partially successful. Pumping began on the 13th and continued, with numerous stoppages for repairs to main pump and engines, until the 23d. After a careful examination of the main engine, it was found that one of the crank disks of the built-up shaft had twisted on the pin, thus throwing the whole crank shaft out of line. It was decided to take the dredge to Memphis and have the shaft repaired. These repairs were completed on October 9, and on the 10th the dredge was taken to Island No. 40 and dredging begun the same day. Dredging continued until the 14th, when, owing to a rising river and the work contemplated having been completed, the dredge was taken to the bank to await developments. Dredging was resumed on the 19th, and consisted in widening and deepening the channel already dredged. This was continued until the 26th, when a rising river rendered further dredging unnecessary. As the indi-

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cations were that the rise would continue for a considerable period, it was decided to retire the dredge for the season. She reached New Madrid October 31, when the crew was discharged and the dredge laid up in ordinary.

Dredge Beta.—This dredge was not in commission during the season.

Dredge Gamma.—This dredge left New Madrid September 16, arriving at the chute of Island No. 40 on September 18. At this point it was decided to attempt to fill above the wreck of the *City of Hickman* and in what was the channel the previous season. Dredging was commenced on the 19th and continued until the 26th. Results obtained were satisfactory. The old channel was entirely closed and did not again open during the season. The dredge left for Wilsons Point, La. (531), on the 27th, arriving there October 3. Dredging began on the 4th and continued until the 7th, when the work contemplated was completed. The results obtained here were most satisfactory. The surveys made before dredging show only 9 feet in the crossing. A channel 15 feet deep was dredged across the bar, which steamboats began using immediately and continued to use until the end of the low-water season. An examination made of this locality as late as November 27 showed the dredged channel still in existence, though there was some indication of shoaling below it. After completion of this work, dredge was towed to Fleeces Crossing (243), and began dredging on the 19th. On the 20th the piston head of the low-pressure cylinder of the jet engine was broken. Dredging was continued without a jet until the 22d, and with no apparent difference in the rate of progress. Dredging was discontinued on the 28th on account of rising river. The work contemplated had been very nearly completed, and the results attained were quite satisfactory. Plates 31 and 32 of the survey, made before and after dredging, shows quite plainly the work done at this point. This channel was also maintained to the end of the low-water season, and gave no further trouble.

The dredge was towed to Cow Island Bar on October 30, where she was engaged in a capacity test until November 3. The plant was then taken to the chute of Island No. 40, where dredging was begun on the 12th and continued until the 16th, when, owing to rising river, work was discontinued. The cut was made much lower down on the crossing than the old channel, and surveys made after dredging show a channel nearly 9 feet deep at mean low water and directly in line with the current. The river having fallen sufficiently, dredging was resumed December 7 and continued until December 20, when work for the season was discontinued. This last dredging was for the purpose of widening and deepening the cut previously made. An immense amount of drift was encountered buried in the sand. Fifty-four logs were removed, varying in diameter from 8 to 50 inches, and having an aggregate length of over 1,500 feet. The dredge outfit is poorly adapted to snagging work, and it necessarily consumed a great deal of time. It is believed, however, that the results attained warranted the means used. A broad, straight channel was made across the bar, with every indication that it would be maintained. The dredge was retired from active service and laid up in ordinary on December 22.

Dredge Delta.—This dredge left New Madrid September 3 and arrived at Island 34 (179) on the 4th. Dredging was commenced on the 5th and continued until the 22d. The record of this dredge for this time is one of almost constant and aggravating delays, caused by breaking of agitating machinery. The material encountered here was sand, gravel, and lignite, with numerous obstructions, such as logs, stumps, and the wreck of one coal barge containing coal. The nature of the material encountered is doubtless responsible for a large part of the breakdowns. Subsequently a few minor changes were made in the agitating machinery, and the delays from this cause were very much reduced. The work contemplated was completed on the 22d, notwithstanding the many vexatious delays. The results obtained were very satisfactory, as there was at that time 12 feet through the dredged channel. On September 25 the dredge began filling the old channel along Island 34. This filling was quite successful, temporarily, as the depth was reduced from 8 feet to 4 feet in four days' dredging. It is thought, however, that the next rise in the river carried nearly all the filled material away, as subsequent surveys show very little effect of this work. On the 29th, owing to rising river, the dredge went to the bank to await developments. Dredging was resumed October 5 and was confined to deepening the channel previously made, in which, on account of the stage of water, the desired depth had not been attained. A single cut 3,325 feet in length was first made, connecting the upper and lower pools; five short cuts were then made across the blue-clay ridge, which extended diagonally across the river from the upper part of the bar. This ridge is of very tough material, which does not readily scour under the action of the current. This work was completed on the 11th, and at that time there was a good 13½-foot channel except at the lower end of the dredged cut, which had apparently filled somewhat and was afterwards cut out by the *Zeta*. The dredge remained at the bank, awaiting some repairs to cutter machinery and a lower stage of water, until the 21st, when she was taken to Mrs. Hickman's crossing (131), arriving on the 22d and beginning dredging the same day, completing the work on the 24th. The results at this crossing demonstrate the high capacity of this dredge in

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clean material. Surveys made after dredging show a channel 9 feet deep at mean low water, 250 feet wide. On the 29th the dredge was taken to the towhead of Island 18, opposite Cottonwood Point (121.5), where a capacity test was made. After the completion of this test the plant remained at the bank until November 17, when it was taken to winter quarters in West Memphis and laid up in ordinary. In spite of the unenviable record of delays for repairs, this dredge has proven highly efficient and well designed, and with some slight changes in the agitating machinery, which have been suggested by experience, it is believed that it will prove to be one of the most satisfactory ones in operation. The main pump and engines are especially well designed for the work and show very little signs of wear, and this of a nature which, owing to the construction, is readily and cheaply repaired.

Dredge Epsilon.—This dredge left New Madrid September 3 and arrived at Point Pleasant, Mo. (79), the same day. The project here contemplated cutting a channel across Upper Point Pleasant Bar somewhat lower down than the one in use at that time. Dredging was commenced on the 4th and the cut completed on the 12th, when, owing to rising river, the dredge went to the bank. On the 16th dredging was begun at Lazelles (83) and completed on the 21st. The dredge was then moved back to Upper Point Pleasant Bar to widen out the lower end of the cut previously made. Dredging was commenced the same day and completed on the 25th. On the 28th the dredge began pumping in chute behind Point Pleasant Towhead, in an attempt to fill the channel through the chute, and continued until October 6. The dredge moved an immense amount of material and filled completely behind the discharge pipe, but it is not thought that there was any effect on the amount of water flowing through the chute, as it was simply thrown over against the opposite bar, where the current scoured out either the bottom or bar enough to compensate for the contraction caused by the filling. On October 6 dredging was begun at Phillips Bar (82) and a channel 13½ feet in depth over the bar completed on the 8th. On the same day dredging was resumed at the lower end of the channel previously made at Upper Point Pleasant Bar. On the 9th a narrow slit about ⅛ inch by 18 inches was found to have been worn through the pump casing by the action of the sand and gravel. This was repaired with a patch of boiler steel by October 12, but owing to high stage of water dredging was not resumed until October 19 and continued until October 23, when, as there was a good 13½-foot channel over the crossing, she again went to the bank and remained until November 23, when a capacity test was begun at bar below Phillips Towhead. This test was completed on the 28th. Dredging was agian resumed at Upper Point Pleasant Bar on December 5 and six cuts completed on December 6. At the conclusion of this work there was not less than 15 feet in the channel in this vicinity. The dredge remained at the bank until December 13, when she was taken to winter quarters at West Memphis and laid up in ordinary.

It will be noted that this dredge remained throughout the season in what is known as the Point Pleasant country. This part of the river in the previous two or three years had given more trouble to steamboat men than any stretch of the river below Cairo. The results attained by the dredge were entirely satisfactory. At no time was there less than 9 feet in the channel, and at no time did the dredge fail to promptly open a channel from 12 to 15 feet in depth, which was in each case maintained until partly obliterated by rising river.

Dredge Zeta.—This dredge left New Madrid on September 12 and arrived at Mrs. Hickman's crossing (131) the same day. On the 9th only 8½ to 9 feet could be found in the channel at this point, and the project contemplated cutting across the bar, which was very narrow. At the time the dredge was placed in position the channel had cut out to 16½ feet, and no dredging was done, and the dredge remained at the bank until the 23d, when she was towed to Elmot Bar (161). Dredging was begun on the 26th and at a point considerably above the channel heretofore used. A new channel, 150 feet wide and 9 feet deep at mean low water, was successfully opened on October 5. From the 5th to the 8th the dredge lay at the bank repairing a broken joint in discharge pipe in engine room and waiting developments. On the 8th dredging was resumed, widening out lower end of cut. This work was continued until the 11th. Results attained at this bar were very satisfactory, and a channel 12 feet deep was maintained throughout the low-water season without further dredging. On October 12 the dredge was sent to Island 34 to deepen the lower end of the cut made by the *Delta*. This work was completed on the 19th and the dredge sent to Cherokee Crossing (89). Dredging was commenced here on the 22d and suspended on the 25th on account of rising river. The dredge remained at the bank until November 3, when a capacity test was begun at Cherokee Bar, extending until the 6th. The dredge remained at the bank until November 17, when it was towed to the foot of Presidents Island, where another capacity test was attempted, but owing to unsuitable material it was abandoned and the dredge laid up in winter quarters on November 23.

At the beginning of the season this dredge was equipped with both a mechanical agitator and jet agitator. At Elmot Bar the material was fine, comparatively loose

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sand, with no obstructions, but even with this most favorable material the mechanical agitator failed to operate continuously for more than three hours without breakage, and finally, after numerous attempts to remedy the inherent faults of both design and construction, they were abandoned, the machinery removed and discarded. The jet agitator, which is the same as on the dredge *Epsilon*, and described in previous reports, worked very satisfactorily.

SUMMARY OF RESULTS.

In discussing the results of the dredging for the season, it must be borne in mind that the year was not one of extreme low water, the lowest reading on the Cairo gauge being 7.67 feet. This fact, however, does not necessarily mean that there should have been proportionately more water in the channel than in years of lower gauge readings, for the season was one of constant fluctuations in stage. These conditions, as is well known, tend to produce less water over shoal crossings than does a slowly falling or stationary river, even though it may reach a much lower stage as read on the gauge. It seems to be the impression of all steamboat men who were interviewed on the subject that, with the same gauge readings, there was a greater depth of water over the crossings during the low-water season of 1898 than there had been for a number of years previously. How much of this was due to the work of the dredges can only be surmised, but that they are entitled to credit for some of it will hardly be denied.

At no time during the season, as far as known, was there less than 8½ to 9 feet in the channel, and at no time where a bar was attacked by a dredge did it fail to open a channel across it having a depth of not less than 12 to 13½ feet of water. Experience also indicates that this dredged channel, if properly located, will be maintained without further work as long as the river continues to fall or remains stationary, but is very apt to be partly obliterated by a rising river if the rise amounts to more than a few feet. The proper location of the dredged cut is the most important feature connected with the dredging operations. No rule can be laid down for these locations, as they depend on the conditions existing at each bar under consideration. Success in this direction can only be acquired from experience and a careful study and observation of the natural movement of the channel under various circumstances.

CAPACITY TESTS.

In these tests the purpose was to obtain the working capacity of the dredges in clean sand and in water without current. The determination of this quantity has been made by careful surveys just before and immediately at the conclusion of the several tests, covering the field affected by dredging. The distribution of the total volume thus measured over the total time actually dredging should give the true working capacity of the dredge in this material in yards per hour.

Dredge Gamma.—The place selected for testing the *Gamma* was Cow Island Bar (248), where, under a point extending out into the channel between the bar and left bank, a location was found where results of test would not be affected by the current. The dredge was placed in position and dredging begun at 4 p. m., October 31. Considerable time was lost on account of suction head becoming choked with logs and small drift, but it is thought that the test approaches very nearly to the conditions found in practice, and therefore the capacity attained probably represents nearly the amount attained in ordinary channel work.

At 8 a. m., November 3, after making eight cuts aggregating 4,566 feet, covering forty-five hours and thirty minutes actual dredging, the test was discontinued. The material moved during the test was chiefly fine sand, with a very small quantity of blue mud. The total volume moved, from surveys, was 45,856 cubic yards, a rate of 1,008 cubic yards per hour. Other data pertaining to this test, including computation of cost, appear in a following consolidated table of results of tests.

After the completion of capacity test the *Gamma* was moved to point of bar for the purpose of making a test to determine the practicability of cutting into a sand bar above water. With suction lowered to 12 feet the dredge began to pull into the dry bar, and after working one hour and fifty minutes had cut into the bar a distance of 45 feet. This test was then discontinued on account of the very large amount of small drift encountered buried in the sand, it having been demonstrated that the dredge could penetrate a dry bar. At the point where the dredge entered, the bar was bluff and about 2 feet above the water surface; the height of bar increased to about 4 feet above the water at the bow of the dredge when the test was concluded.

Dredge Delta.—The location selected for the test of this dredge was a pocket below a dry sand bar back of the towhead of Island 18 (121½). At the time of the test there was no current through this pocket, and the material shown to have been moved, as determined by the surveys immediately before and immediately after

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dredging, must have been moved by the dredge. In this pocket there was a narrow pool about 100 feet in width and 10 to 14 feet deep extending along the shore of the towhead. Outside of this the water rapidly shoaled to 6 feet and less. Dredging was done on the bar side and near the head of this pool, the effect of each cut being to further increase the width of this deep water. The material encountered was mostly fine sand, averaging perhaps somewhat finer than what is known as channel sand, with some coarse sand and gravel.

The test was begun at 1.10 p. m., October 30. After a run of forty-eight minutes the test was temporarily suspended, owing to the breakage of the cap on the starboard bearing of cutter shaft. Repairs were made and test resumed at 8.10 a m. on the following day. At 12.10 a. m., November 2, at the completion of the fourth cut, the test was brought to a close.

During the first two cuts no attempt was made to crowd the dredge at all, while on the third cut the dredge was pulled ahead faster, and during cut No. 4 the rate of advance was as high as could be maintained without sinking the discharge pipe, which during this last run was floating very low in the water. The aggregate length of the four cuts was 2,711 feet, and the total time of actual dredging was twenty-seven hours and twenty-three minutes.

A computation of the quantity of material removed was made by plotting cross sections 50 feet apart as obtained from the depths shown by the surveys before and after the test. This method gave 34,365 cubic yards as the total volume moved. This was checked by measuring with a planimeter the contour areas within the dredged area on the before and after dredging maps, which method gave 34,560 cubic yards. Thirty-four thousand four hundred and sixty-two cubic yards, the mean of these two determinations, is accepted as the total volume moved during the test, which quantity gives 1,259 cubic yards as the average quantity moved per hour for the time actually dredging. For cut No. 4, distributing to it that proportion of the total volume to which it is entitled from considerations of its average depth of cut and rate of advance, we have 2,550 cubic yards as the quantity moved per hour, which is probably very near the capacity limit for the dredge in this material. The capacity of the dredge, however, seemed to be limited only to the ability of the pontoons to carry the dredged material away.

Dredge Epsilon.—This dredge was tested in a pocket at the foot of Phillips Towhead (81), in which there was no perceptible current, between a flat bar on the left and a bluff bar on the right. Dredging was begun near the flat bar, but there was so much mud with the sand that the material would not cave readily to suction, and the cut was abandoned and the dredge moved over to the right as close to the bluff bar as possible, where the test proper was begun at 4.10 p. m., November 26. The material encountered was medium coarse sand with occasional fine sand and some mud. While on the second cut a long delay was occasioned by the nipple of quick coupling at stern of dredge coming loose from rubber joint. Wind and rain made work on this very slow, and eight hours and forty minutes were lost in making necessary repairs. There were no further delays of any importance, except such as are incidental to dredging operations in water without current, such as difficulty in dropping back in slack water in changing cuts and in keeping discharge pipe from buckling.

Test was concluded at 2.50 p. m., November 28, after making four cuts having a total length of 2,015 feet. The time employed in actual dredging was twenty-four hours and fifty minutes. The volume of material moved, computed from cross sections of the before and after dredging surveys, 25 feet apart, was 32,407 cubic yards, or 1,305 cubic yards per hour.

Dredge Zeta.—The dredge *Zeta* was tested near the head of a pocket below Cherokee Towhead (89 R.), in which there was from 9 to 13 feet of water and no current.

The primary purpose of the test of this dredge at this point was to determine the practicability of dredging through a dry bar, and second, to measure the capacity of the dredge in cubic yards per hour. At the point selected for the test the bar was bluff and about 4 feet above the water surface. The head cables were attached to deadmen placed on dry bar, and anchors were set out on either side of dredge on the bar and side lines made fast to them. Test was begun at 2.20 p. m. November 3, and the work was continued until 4 p. m. November 6, when, after sixty-two hours and fifty-five minutes actual dredging, six cuts had been made, having a total length of 1,785 feet.

For the purpose of demonstrating the feasibility of cutting across a dry bar the test was entirely successful. A hole was cut in the dry bar approximately 500 feet long, 140 feet wide at top, and having a depth of from 3½ to 4 feet above water and 13 feet below water along the axis of cuts, the sides under water standing at a considerable angle to the vertical. It would have been altogether practicable to cut a channel entirely across the bar, had it been so desired, to the deep water on the opposite side, a distance of 1,200 feet.

For the purpose of determining the working capacity of the dredge, the test was

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not as successful, and the results obtained can not be regarded as applying to work on submerged bars of channel sand. The total volume moved was 40,991 cubic yards, a rate of only 652 cubic yards per hour, due largely to the character of the material encountered. The composition of the bar above water and to a depth of about 7 feet below the water surface was pure sand, but beneath this was a layer of blue mud, which probably extended down as deep as the suction head was lowered, from 16 to 17 feet. Had the suction been raised sufficiently high to clear the blue mud a higher capacity would have been obtained.

From the records kept during the dredge tests, and from the results of computations of volume moved during test operations, the following table has been compiled. All gauge readings have been reduced to their equivalent in feet of water, and corrections made to refer all discharge and suction heads to the water surface. In computing the matter of cost, the items of fuel, pay roll, subsistence, lubricants, lighting supplies, and repairs were taken into account, but the hire of tender has not been included.

This report is accompanied by the following tables: Summary of dredging operations, distribution of expenditures, summary of cost of dredging operations, abstract of expenditures, and consolidated table of dredge tests.

Very respectfully submitted.

F. B. MALTBY,
Assistant Engineer, Superintendent of Dredging.

Capt. MASON M. PATRICK,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission, St. Louis, Mo.

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TABLE No. 10.—*Summary of dredging operations, Mississippi River, below Cairo, during low-water season of 1898.*

Plant.	Alpha, Sept. 10 to Oct. 31.	Gamma, Sept. 16 to Dec. 22.	Delta, Sept. 3 to Nov. 18.	Epsilon, Sept. 3 to Dec. 15.	Zeta, Sept. 12 to Nov. 22.
Moving into field and retiring to winter quarters.....hours..	145	76	79	51	60
Classified time, dredging operations.....do....	697	2,276	1,769	2,445	1,668
Extensive repaire at Memphis.....do....	406	.....	.....	.....	.....
Total.....do....	1,248	2,352	1,848	2,496	1,728
Total distance towed.....miles..	403	808	279	183	357

ALPHA.

Points of operation.	Placing plant.	Dredging.	Changing cuts.	Repairs.	Making up tow.	Towing..	Not working, awaiting lower stage river.	Total.	Number of cuts.	Total length cuts.	Average rate advance per hour.	Average depth of suction.	Average depth of cut.	Average steam pressure.	Average speed of main pump, revolutions per minute.
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*		
Peters Towhead (271.5).....	39	85	14	104	17	.....	.....	259	12	4,600	52.4	12.0	2.82	142.3	141.0
Island 40 (213), first time.....	7	77	14	5	14	5	101	223	11	5,492	63.0	12.0	2.6	138.2	133.0
Island 40 (213), second time.....	5	130	20	13	8	1	38	215	17	9,735	77.6	12.0	1.7	139.0	137.6
	51	292	48	122	39	6	139	697	40	19,827	.....	.....	.....	.....	.....

GAMMA.

Island 40 (213), first time.....	19	110	16	16	9	2	46	212	12	7,895	71.6	13.2	6.7	142.3	143.7
Wilsons Point (530).....	5	54	3	7	4	102	69	244	6	5,125	95.7	14.9	1.94	144.0	156.0
Fleeces Crossing (243).....	21	143	25	53	3	199	105	549	11	10,885	76.5	15.0	2.82	147.0	154.0
Cow Island Bar (248), test.....	25	47	10	10	5	2	22	121	8	4,566	100.3	15.0	7.16	145.6	150.0
Island 40 (213), second time.....	5	81	6	5	2	32	659	790	6	5,935	82.5	15.0	2.13	149.6	156.0
Island 40 (213), third time.....	10	a 273	10	1	3	.....	63	360	7	7,135	51.0	15.0	2.97	149.3	150.0
	85	708	70	92	26	337	958	2,276	50	41,541	.....	.....	.....	.....	.....

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DELTA.

Island 34 (179), first time	18	219	49	125	4	1	88	499	18	12,035	57.0	14.9	4.55	150.8	134.0
Island 34 (179), filling side channel	14	64	14	4	5	1	125	227	5	3,550	59.2	13.7	6.17	145.0	140.8
Island 34 (179), second time	12	108	15	21	6	1	213	376	5	7,095	74.8	15.5	4.63	149.2	147.7
Hickman Crossing (131)	14	39	5	10	3	32	111	214	4	3,795	74.4	15.5	4.47	152.0	154.3
Test at Towhead of Island 18 (121.5)	10	30	10	18	.....	6	379	453	4	2,711	99.0	13.6	6.55	151.1	140.9
	63	460	93	178	18	41	916	1,769	31	28,186	.....	.....	.....	.....	.....

EPSILON.

Point Pleasant Bar (79), first time	4	113	41	24	4	.....	127	313	20	13,950	132.0	15.1	2.5	137.9	177.4
Lazelles Bar (83)	6	80	12	14	4	1	.....	117	11	7,822	100.0	15.0	3.0	132.4	162.0
Point Pleasant Bar (79), second time	5	64	27	3	2	.....	68	169	10	7,607	112.0	15.0	3.0	135.4	165.0
Chute behind Point Pleasant Towhead (79), filling	4	147	18	22	4	.....	.....	195	12	4,000	21.0	15.0	8.0	135.0	165.0
Phillips Bar (82)	3	35	4	1	2	2	.....	47	4	2,725	85.0	15.0	4.5	130.0	165.0
Point Pleasant Bar (79), third time	3	24	2	79	1	.....	151	260	3	1,885	89.0	15.0	5.5	122.3	168.0
Point Pleasant Bar (79), fourth time	5	92	7	16	4	.....	642	766	14	8,159	92.0	15.0	4.5	124.0	163.0
Test at Phillips Towhead (82)	6	28	11	14	4	1	297	361	4	2,015	81.0	17.0	9.6	130.0	178.0
Upper Point Pleasant Bar (79)	4	24	2	.....	5	.....	182	217	6	3,621	151.0	17.0	2.5	131.7	178.0
	40	607	124	173	30	4	1,467	2,445	84	51,784	.....	.....	.....	.....	.....

ZETA.

Elmot Bar (160)	32	250	39	59	7	7	306	700	7	20,650	81.8	15.3	3.93	143.9	179.9
Island 34 (179)	12	129	8	26	8	3	5	191	4	9,775	80.1	15.3	4.10	147.6	183.6
Cherokee Crossing (89)	14	46	7	.....	6	52	215	340	8	9,425	206.0	16.0	3.6	147.5	171.7
Test at Cherokee Bar (89)	4	63	7	2	4	2	242	324	6	1,785	33.5	17.0	20.6	146.8	179.0
Test at Presidents Island (240)	6	22	.....	11	6	33	35	113	1	1,018	53.0	14.5	5.94	145.0	190.0
	68	510	61	98	31	97	803	1,668	26	42,653	.....	.....	.....	.....	.....

a This item includes 133 hours removing logs and snags from channel.

"Placing Plant" includes the time after arrival at bar, from commencement of setting piles, till dredging is begun.

"Dredging" includes time employed in removing obstructions encountered, and in examination of suction head, in addition to the time pulling ahead.

Each bar is charged with the time towing from previous bar.

The average rate of advance is computed from the time actually pulling ahead.

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TABLE No. 11.—*Summary of cost of dredging operations during low-water season, 1898.*

Dredge *Alpha*:		
Moving into field and retiring to winter quarters	$1,353.57	
Peters Towhead	2,417.75	
Island 40	4,088.71	
Extensive repairs at Memphis	3,789.99	
		$11,650.02
Dredge *Gamma*:		
Moving into field and retiring to winter quarters	665.92	
Island 40	11,934.05	
Wilsons Point	2,137.96	
Fleece Crossing	4,810.42	
Cow Island Bar	1,060.22	
		20,608.57
Dredge *Delta*:		
Moving into field and retiring to winter quarters	746.99	
Island 34	10,419.98	
Hickman Crossing	2,023.48	
Test at Towhead, Island 18	4,283.35	
		17,473.80
Dredge *Epsilon*:		
Moving into field and retiring to winter quarters	492.54	
Point Pleasant Bar	14,563.68	
Lazelles Bar	1,129.94	
Chute behind Point Pleasant Bar (filling)	1,883.24	
Phillips Bar	453.91	
Test at Phillips Towhead	3,486.40	
Upper Point Pleasant Bar	2,095.69	
		24,105.40
Dredge *Zeta*:		
Moving into field and retiring to winter quarters	632.47	
Elmot Bar	7,378.80	
Island 34	2,013.36	
Cherokee Crossing	3,583.99	
Test at Cherokee Crossing	3,415.33	
Test at Presidents Island	1,191.15	
		18,215.10
Inspection:		
Administration	1,701.14	
Operating inspection boat	13,068.00	
		14,769.14
Surveys:		
Steamers *Search, Vidalia, Patrol, Vulcan, Jim T. Duffy, jr*		13,450.73
Total		120,272.76

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TABLE NO. 12.—*Distribution of expenditures, dredging operations, during low-water season of 1898.*

DISTRIBUTION OF COST.

Plant.	Period.	Labor.	Office supplies.	Subsistence.	Fuel.	Lighting supplies.	Lubricants.	Miscellaneous repairs.	Hire of plant.	Total.
Dredge Alpha	September	$2,392.50	$5.78	$749.03	$550.18	$11.96	$42.02	$119.63	$960.00	$4,831.12
	October	2,700.33	3.63	694.46	1,092.61	34.74	47.53	381.60	1,860.00	6,818.90
Total		5,092.83	9.41	1,443.49	1,642.79	50.72	89.55	501.23	2,820.00	11,650.02
Dredge Gamma	September	2,786.36	11.33	692.22	609.86	12.74	46.31	125.55	1,660.00	5,944.37
	October	2,814.83	1.00	675.87	2,319.93	8.16	38.98	108.91	1,240.00	7,207.68
	November	2,816.50	2.00	565.21	553.70	22.27	25.88	149.40	280.00	4,414.96
	December	2,191.01	.....	466.76	215.28	19.44	50.52	98.55	.....	3,041.56
Total		10,608.70	14.33	2,400.06	3,698.77	62.61	161.69	482.41	3,180.00	20,608.57
Dredge Delta	September	2,880.17	10.78	765.05	1,046.86	19.82	76.21	143.23	1,395.00	6,337.12
	October	2,913.18	.....	731.61	1,492.06	19.14	48.77	110.96	1,395.00	6,710.72
	November	1,781.65	2.33	526.68	880.00	11.76	12.00	266.54	945.00	4,425.96
Total		7,575.00	13.11	2,023.34	3,418.92	50.72	136.98	520.73	3,735.00	17,473.80
Dredge Epsilon	September	2,748.17	12.51	826.59	1,624.06	22.03	90.19	385.52	1,488.00	7,197.07
	October	2,825.34	.....	653.41	1,487.30	28.19	80.15	183.45	1,488.00	6,740.84
	November	2,694.33	.....	671.06	1,663.50	17.55	64.00	149.88	1,440.00	6,701.42
	December	1,663.30	.....	440.34	461.76	6.87	26.13	35.67	832.00	3,466.07
Total		9,931.64	12.51	2,592.00	5,236.62	69.64	260.47	754.52	5,248.00	24,105.40
Dredge Zeta	September	2,578.64	17.79	700.30	695.97	28.40	142.08	440.79	1,511.25	6,115.22
	October	2,868.98	.....	648.74	1,339.62	36.16	102.80	232.62	1,511.25	6,740.17
	November	1,893.29	7.75	519.76	1,805.53	.....	.....	109.63	1,023.75	5,359.71
Total		7,340.91	25.54	1,868.80	3,841.12	64.56	244.88	783.04	4,046.25	18,215.10
Inspection and general administration	July	172.92	.....	31.71	29.50	1.23	.85	.....	.....	236.21
	August	322.58	3.50	93.04	68.90	5.12	1.99	.....	.....	495.13
	September	1,783.41	17.48	856.78	652.84	3.56	6.75	31.82	.....	3,352.64
	October	1,870.50	21.71	832.64	1,528.52	5.25	11.30	64.10	.....	4,334.02
	November	1,884.97	66.55	457.46	812.59	3.90	.....	1.40	980.00	4,206.97
	December	1,034.34	.....	290.28	176.80	2.75	.....	.....	640.00	2,144.17
Total		7,068.72	109.24	2,561.91	3,269.25	21.81	20.89	97.32	1,620.00	14,769.14

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TABLE NO. 12.—*Distribution of expenditures, dredging operations, during low-water season of 1898*—Continued.

DISTRIBUTION OF COST—Continued.

Plant.	Period.	Labor.	Office supplies.	Subsistence.	Fuel.	Lighting supplies.	Lubricants.	Miscellaneous repairs.	Hire of plant.	Total.
Surveys	July	$149.59	$0.50	$31.03	.....	$0.42	$0.20	.....	.....	$181.74
	August	1,625.66	4.24	379.09	$196.25	.....	.....	$7.10	.....	2,230.34
	September	2,380.82	17.99	492.20	466.61	3.66	.88	21.62	$200.00	3,583.78
	October	2,101.67	8.42	508.09	728.09	9.82	3.15	10.70	620.00	3,989.94
	November	1,884.18	3.48	465.03	166.40	5.37	1.40	21.98	500.00	3,047.84
	December	516.00	.....	52.76	39.00	.55	1.40	7.38	.....	617.09
Total		8,657.92	34.63	1,946.20	1,596.35	19.82	7.03	68.78	1,320.00	13,650.73
Grand total		56,275.72	218.77	14,835.80	22,703.82	339.88	921.49	3,208.03	21,969.25	120,472.76

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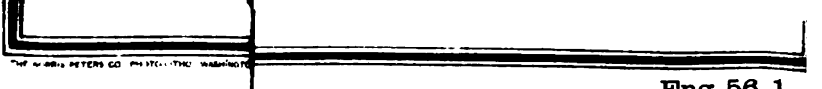

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Table of Gauge Readings of ood Heights and Established Grades

E OF TATION	HIGH WATER 1897	HIGH WATER 1898	HIGHEST KNOWN WATER	E YEAR	ADOPTED H.W. STANDARD	ESTABLISHED LEVEE GRADE
	51.68	49.78	52.17	1883	54.17	56.17
t	44.98	43.98	45.58	1884	48.10	50.10
dridd	40.27	38.86	40.27	1897	42.90	44.90
rood Pt.	39.86	38.58	39.86	"	42.20	44.20
	37.47	35.80	38.30	1908	40.40	42.40
le	37.66	37.57	37.66	1897	41.60	43.60
	41.60	39.06	41.60	"	46.20	48.20
	51.75	49.11	51.75	"	54.10	56.10
wer	47.17	46.00	47.17	"	50.20	52.20
River	52.42	51.06	52.42	"	56.40	58.40
nesCity	51.90	51.14	51.90	"	56.30	58.30
lle	44.75	46.16	44.75	"	50.50	52.50
ovidence	44.54	44.35	44.54	"	48.00	50.00
urg	52.48	49.40	52.48	"	56.05	57.05
pph	47.86	45.10	47.86	"	50.80	52.80
	49.82	47.40	49.82	"	54.00	56.00
anding	50.20	44.30	50.20	"	52.50	54.50
Sara	43.70	37.50	43.70	"	45.70	47.70
Rouge	40.65	34.60	40.65	"	43.20	45.20
aine	36.25	30.60	36.25	"	38.70	40.70
onville	32.75	27.95	32.75	"	34.95	36.95
Point	27.95	23.50	27.95	"	29.90	31.80
ton	19.17	15.90	19.17	"	20.35	22.35
ckson	7.20	6.70	7.20	"	8.00	10.00

Legend

Gauges	⊙	Figured	From	Mean	Gulf Level
Known Water	———	Figures	For	Gauge	Readings.
1897 below H.K.W.	– – – –	"	"	"	"
1898 " "	.....	"	"	"	"
Standard of H.W.	———	"	"	"	"
shed Levee Grade	– – – –	"	"	"	"
1899	— · — · —	"	"	"	"

Hor. Scale $\frac{1}{4}$in - 10M. Ver. Scale $\frac{1}{4}$in - 5 Ft.

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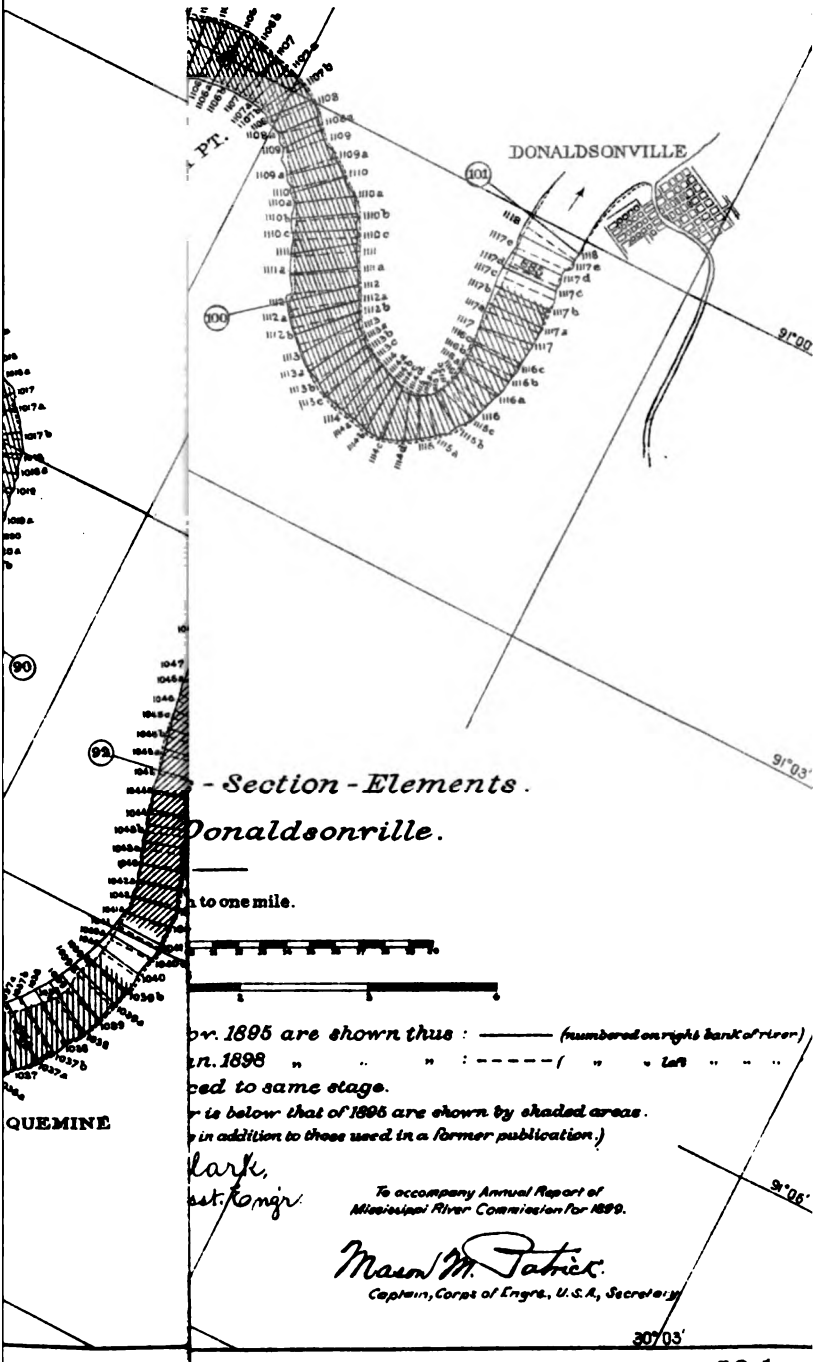

- Section - Elements.

Donaldsonville.

to one mile.

ov. 1895 are shown thus : ——— (numbered on right bank of river)
in. 1898 " " " : - - - - - (" " left " " "
ced to same stage.
r is below that of 1895 are shown by shaded areas.
in addition to those used in a former publication.)

Clark,
Asst. Engr.

To accompany Annual Report of
Mississippi River Commission for 1899.

Mason M. Patrick.
Captain, Corps of Engrs., U.S.A., Secretary.

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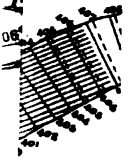

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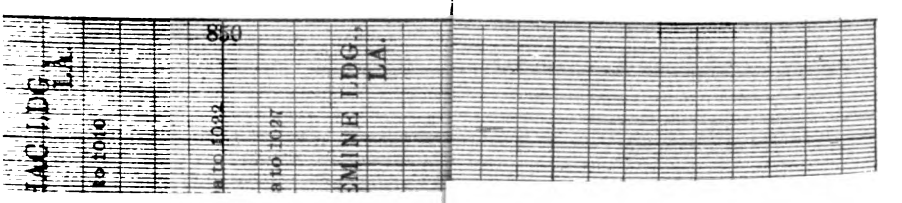

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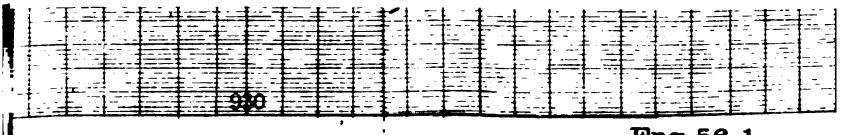
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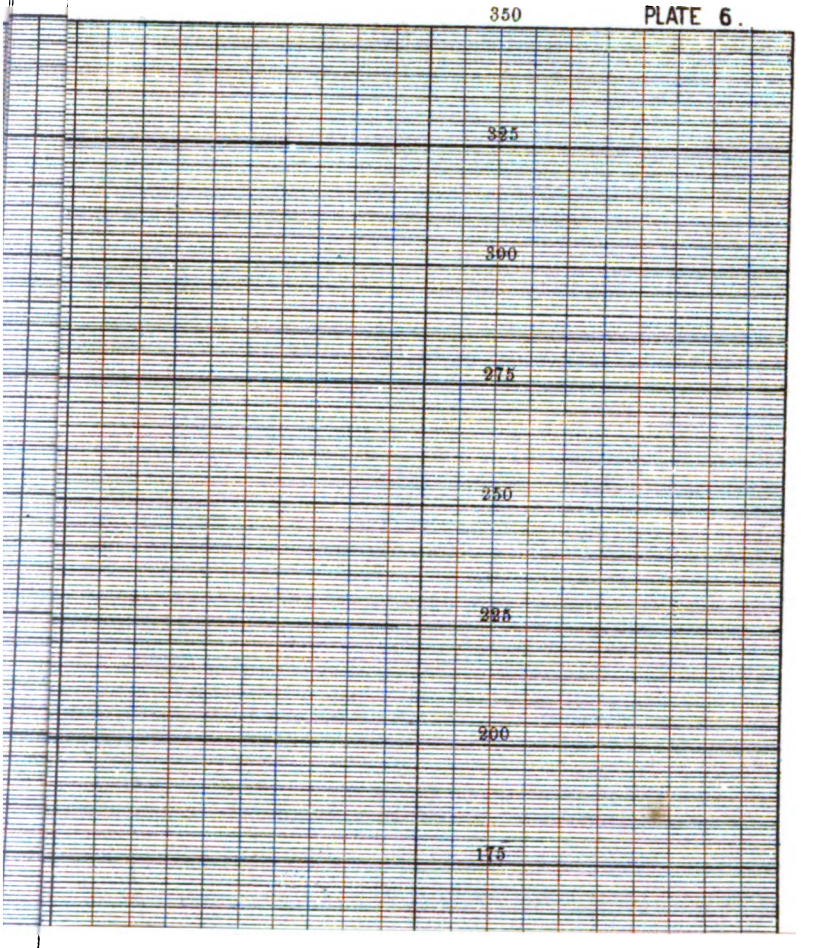
PLATE 6.



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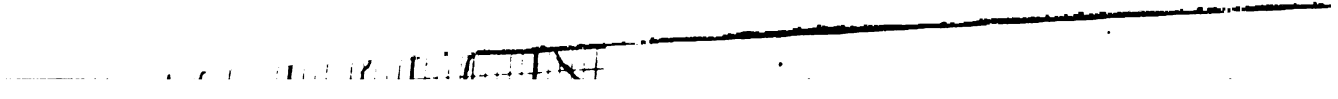

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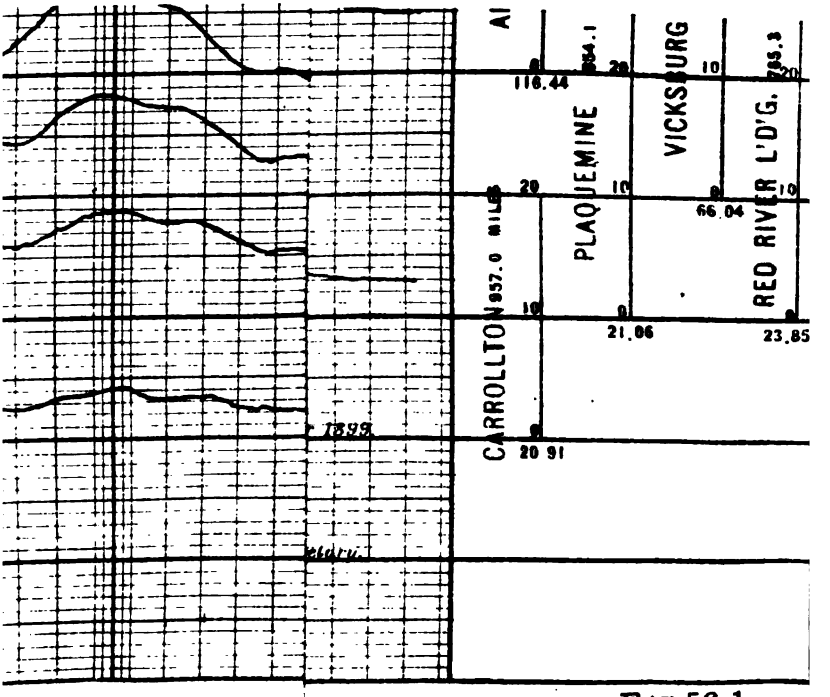

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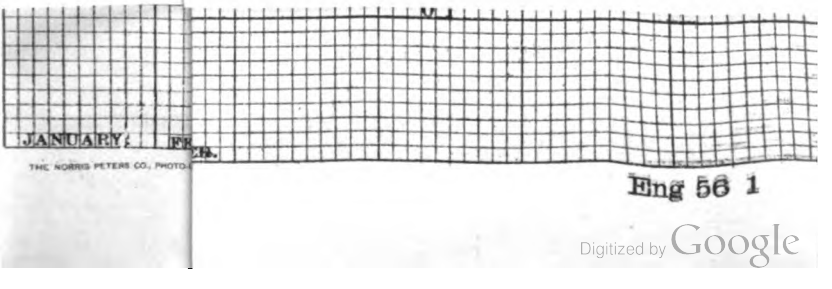

THE NORRIS PETERS CO., PHOTO-

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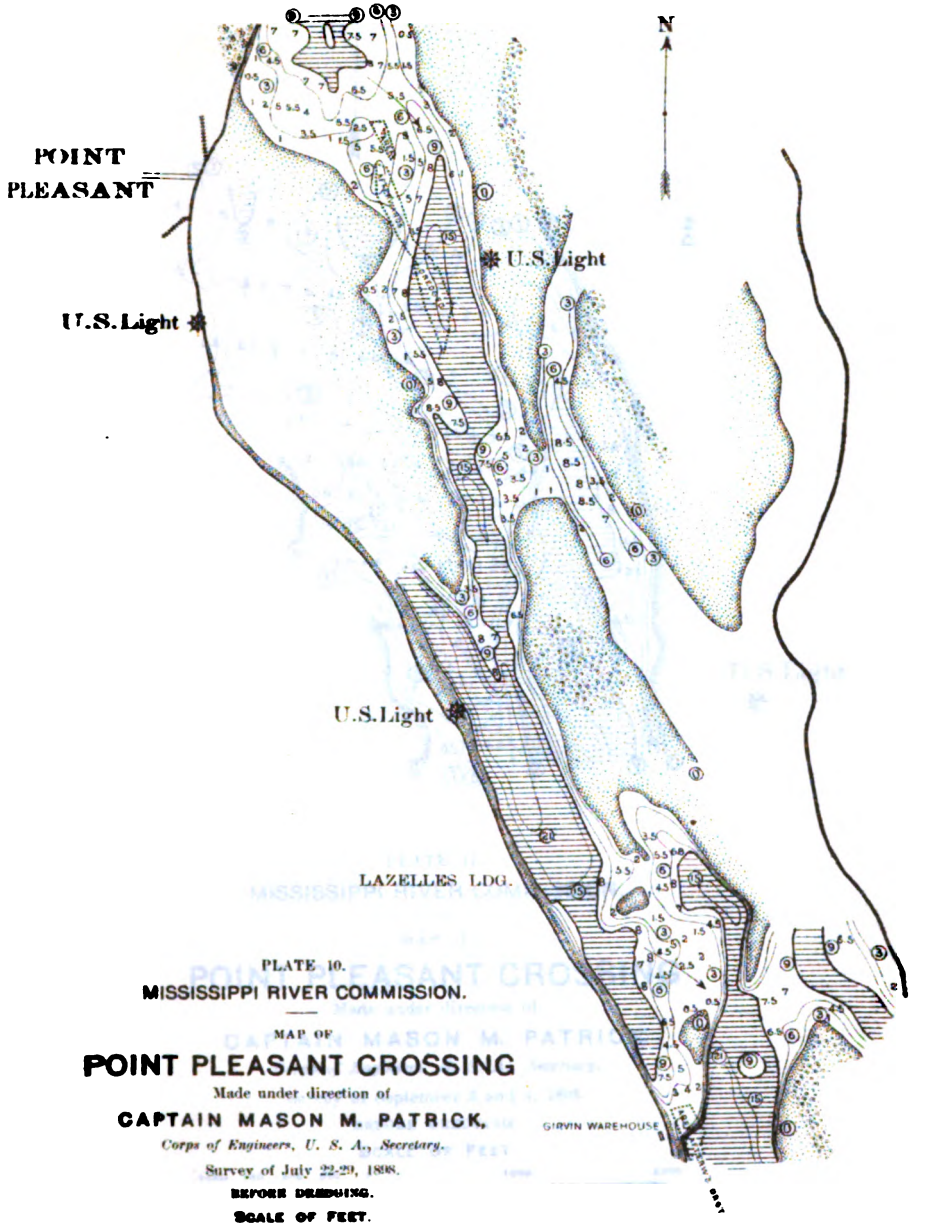

PLATE 10.

MISSISSIPPI RIVER COMMISSION.

MAP OF

POINT PLEASANT CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of July 22-29, 1898.

BEFORE DREDGING.

SCALE OF FEET.

0 4000 8000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the New Madrid gage, which corresponds to a reading of 2.2 feet.

Gage at time of survey was 10.5 feet, or 8.3 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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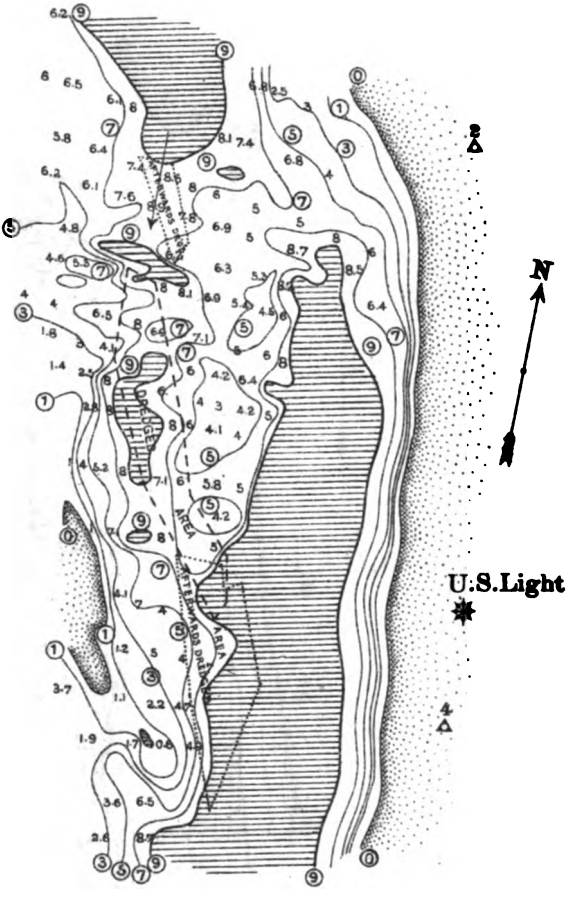

PLATE 12.

MISSISSIPPI RIVER COMMISSION.

MAP OF

POINT PLEASANT CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of September 20, 1898.

TEN DAYS AFTER DREDGING FIRST TIME, ONE DAY BEFORE DREDGING SECOND TIME.

SCALE OF FEET.

1000 700 600 200 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the New Madrid gage, which corresponds to a reading of 2.2 feet.

Gage at time of survey was 10.2 feet, or 8.0 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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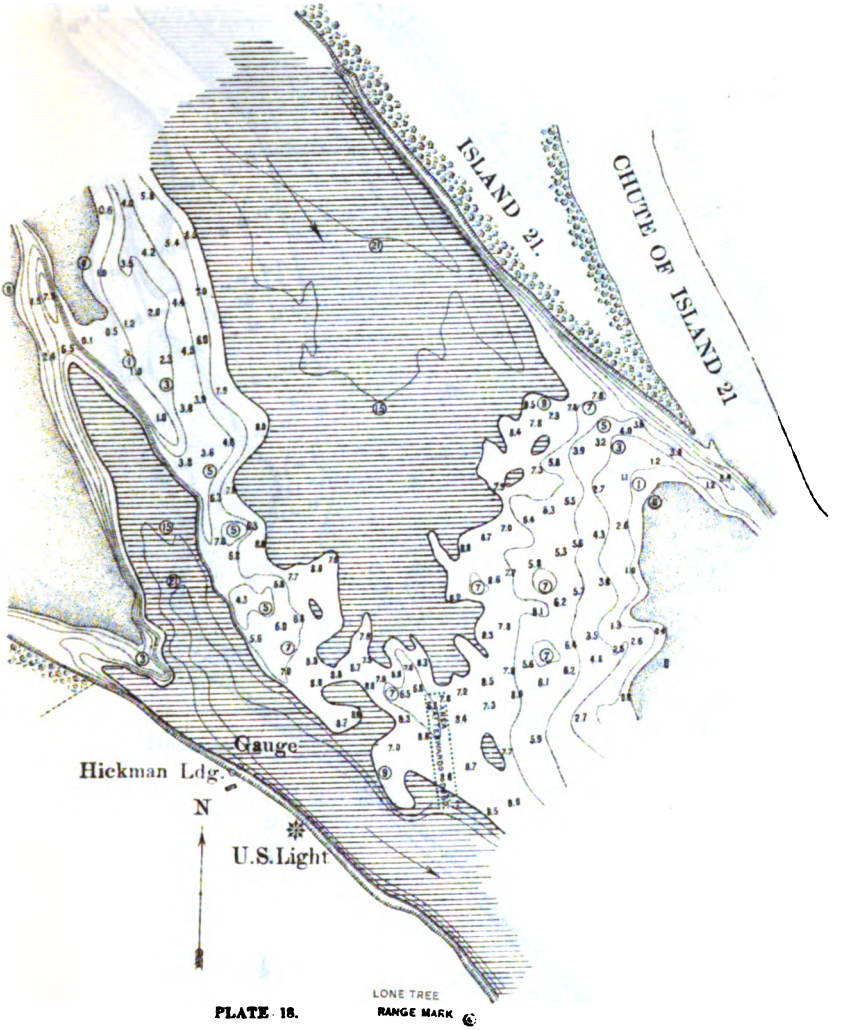

PLATE 18.

MISSISSIPPI RIVER COMMISSION.

MAP OF

HICKMAN CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 21 and 22, 1898.

BEFORE DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Cottonwood Point gage, which corresponds to a reading of 0.4 feet.

Gage at time of sounding was 4.5 feet or 4.1 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

THE WERNER-PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.

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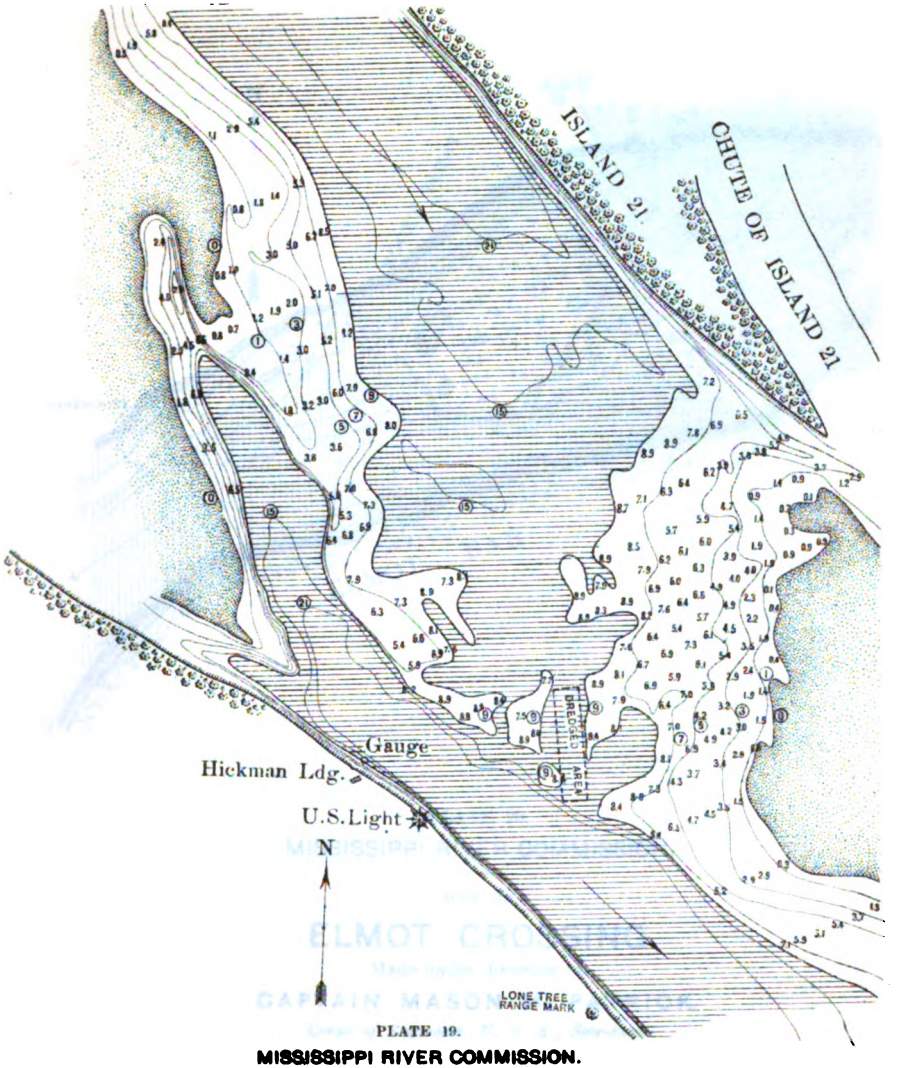

PLATE 19.

MISSISSIPPI RIVER COMMISSION.

MAP OF

HICKMAN CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 27, 1898

AFTER DREDGING.

SCALE OF FEET.

1000 700 400 200 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Cottonwood Point gage, which corresponds to a reading of 0.4 feet.

Gage at time of sounding was 8.5 feet or 8.1 feet above mean low water.

Shaded areas indicate depths below 0 feet at mean low water.

Dotted areas indicate bars above mean low water.

THE WERNER PETERS CO. PHOTO-LITHO. WASHINGTON D. C.

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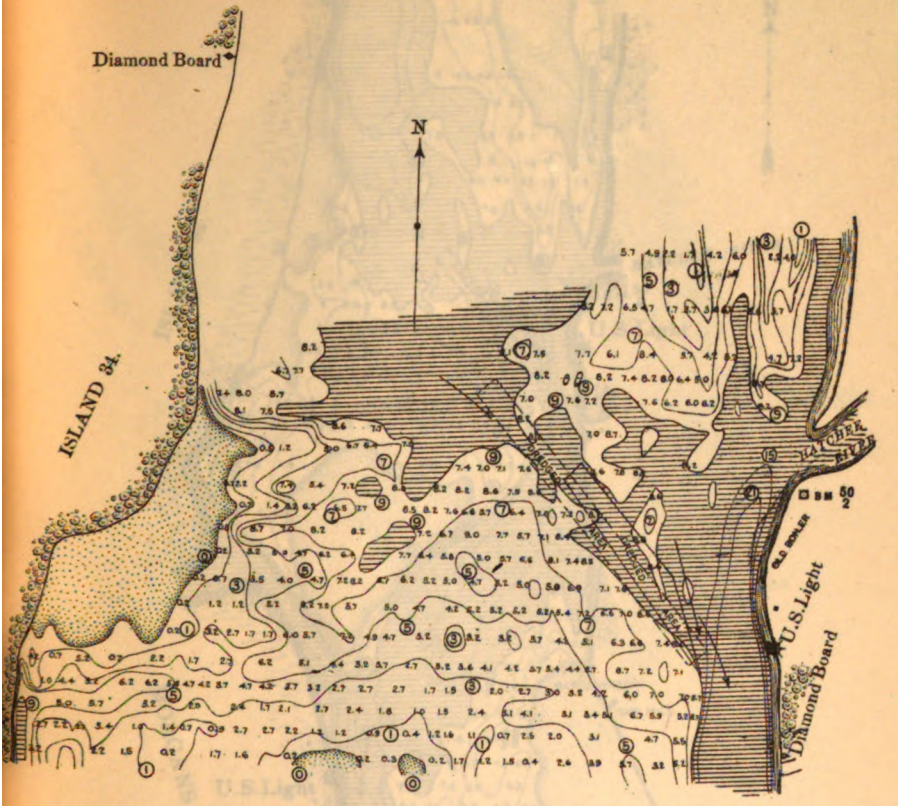

PLATE 25.

MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND 34 CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 18 and 19, 1898.

AFTER DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Fulton gage, which corresponds to a reading of 3.9 feet.

Gage at time of survey was 8.7 feet, or 4.8 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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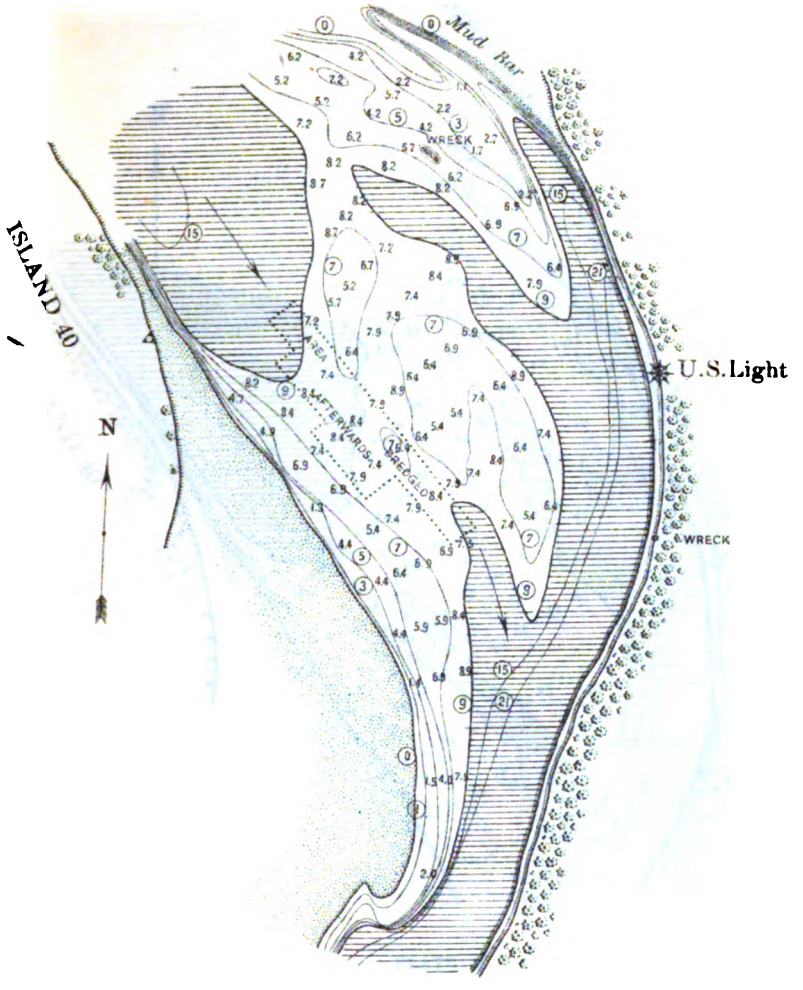

PLATE 28.

MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND 40 CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of November 12, 1898.

BEFORE DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.85 feet.

Gage at time of survey was 7.2 feet, or 5.35 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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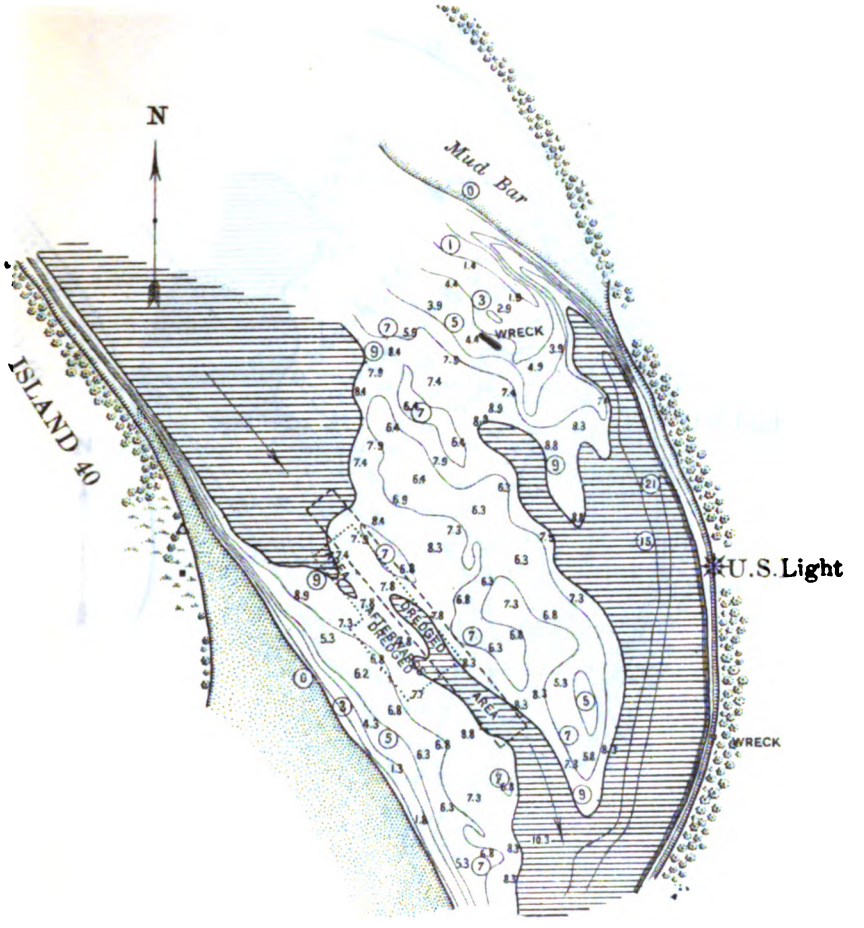

PLATE 29.

MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND 40 CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of November 16 and 17, 1898.

ONE DAY AFTER DREDGING FIRST TIME.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.85 feet.

Gage at time of survey was 9.55 feet, or 7.7 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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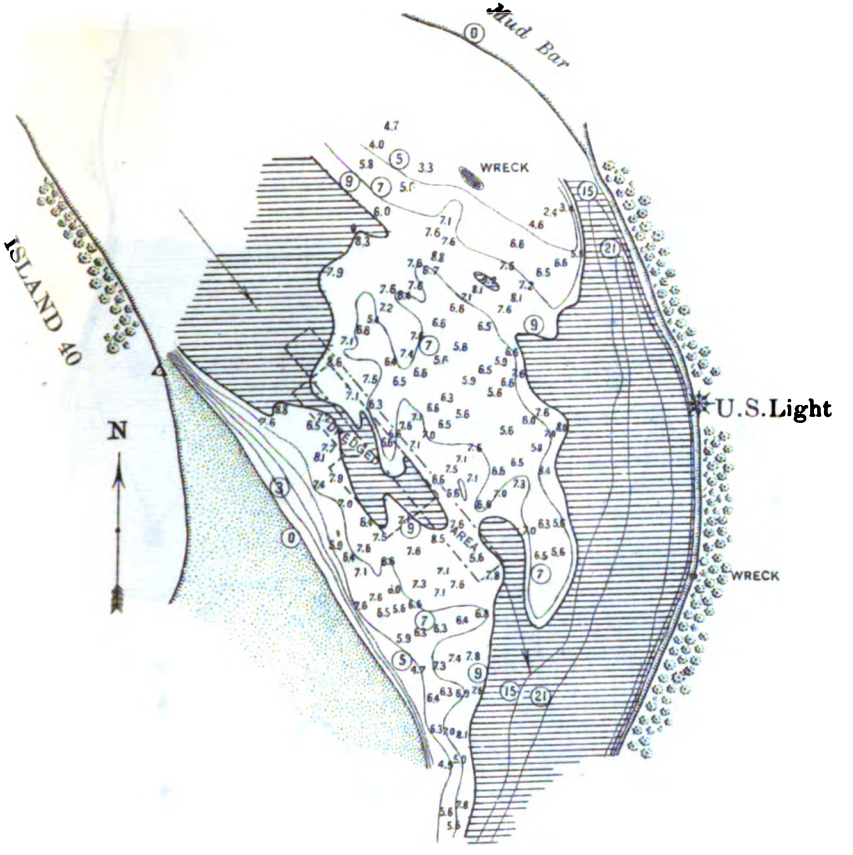

PLATE 30.

MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND 40 CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of December 23, 1898.

TWO DAYS AFTER DREDGING SECOND TIME.

SCALE OF FEET.

1000 500 000 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.85 feet.

Gage at time of survey was 5.88 feet, or 4.03 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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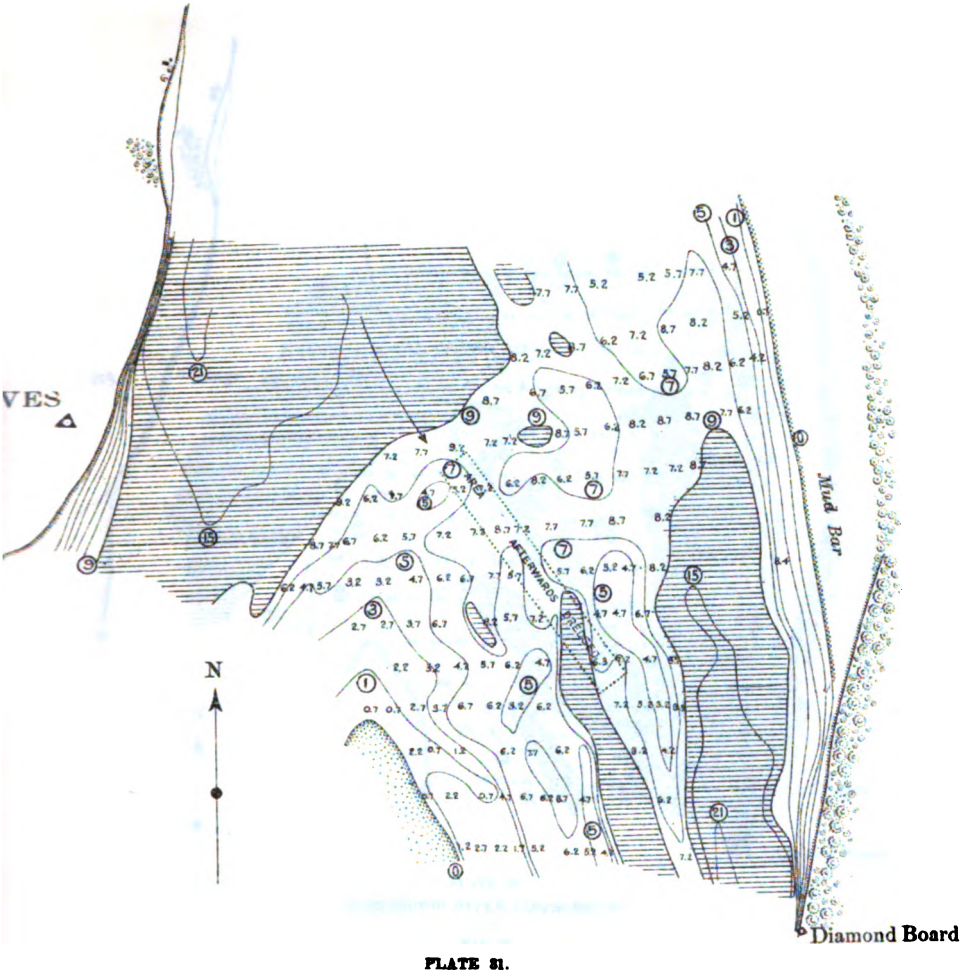

PLATE 31.

MISSISSIPPI RIVER COMMISSION.

MAP OF

FLEECE CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 2, 1896.

BEFORE DREDGING.

SCALE OF FEET.

1000 700 400 200 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.85 feet.

Gage at time of survey was 6.6 feet, or 4.75 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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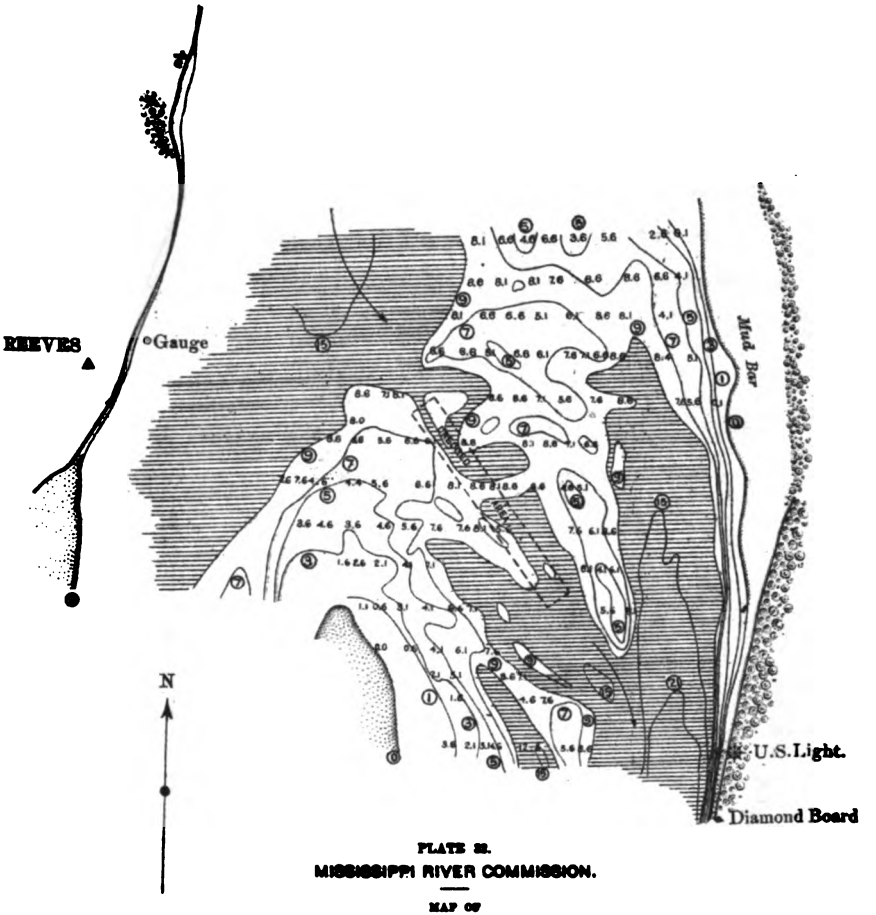

PLATE 32.

MISSISSIPPI RIVER COMMISSION.

MAP OF

FLEECE CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary

Survey of October 31, 1898.

THREE DAYS AFTER DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.35 feet.

Gage at time of survey was 8.35 feet, or 7.0 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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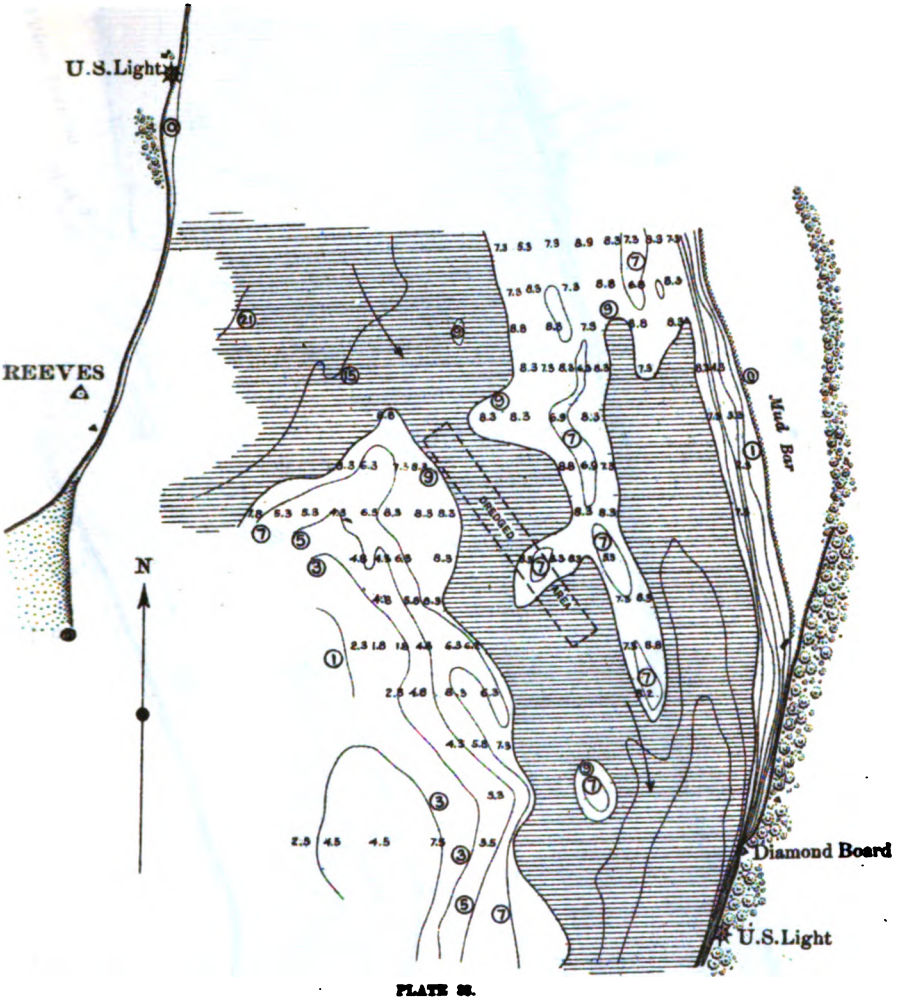

PLATE 32.

MISSISSIPPI RIVER COMMISSION.

MAP OF

FLEECE CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of December 1, 1898.

TWENTY-FOUR DAYS AFTER DREDGING.

SCALE OF FEET.

1000 500 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Memphis gage, which corresponds to a reading of 1.35 feet.

Gage at time of survey was 10.6 feet, or 9.75 feet above mean low water.

Shaded areas indicate depths below 0 feet at mean low water.

Dotted areas indicate bars above mean low water.

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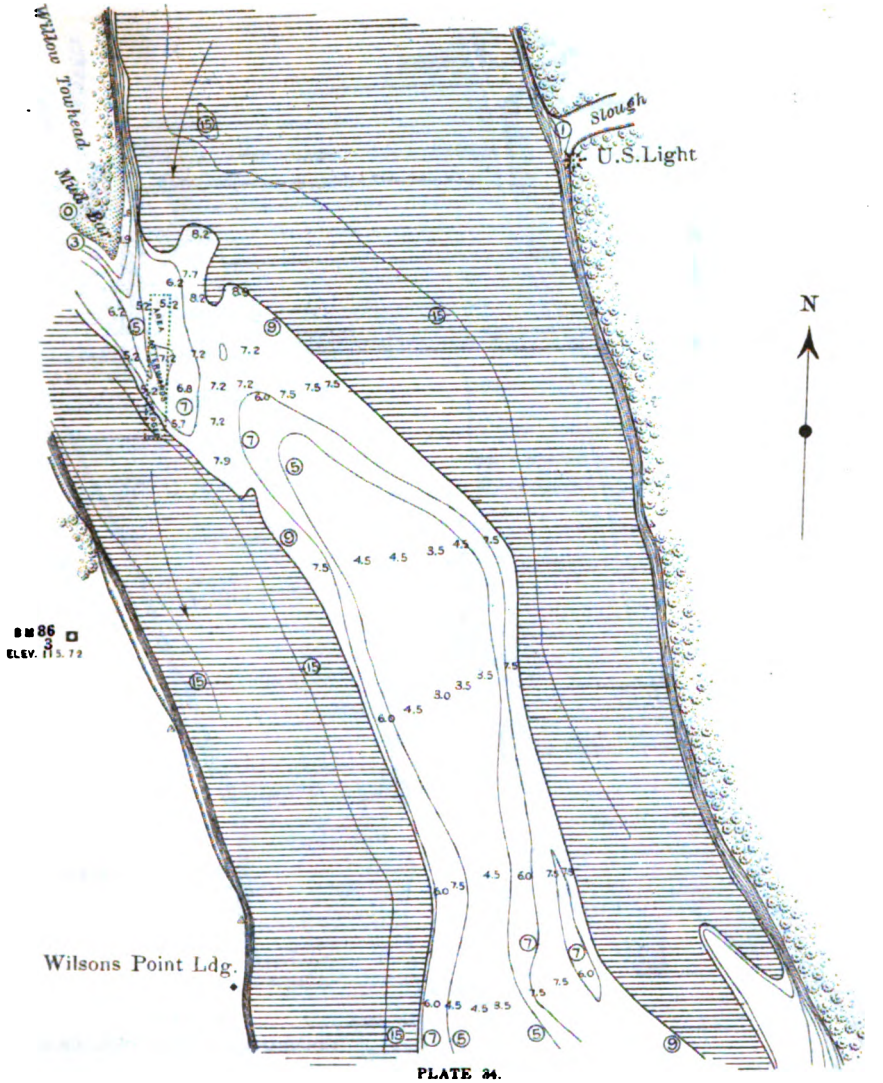

PLATE 34.

MISSISSIPPI RIVER COMMISSION.

MAP OF

WILSONS POINT CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 1 and 3, 1896.

BEFORE DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Lake Providence gage, which corresponds to a reading of 2.1 feet.

Gage at time of survey was 8.0 feet, or 5.9 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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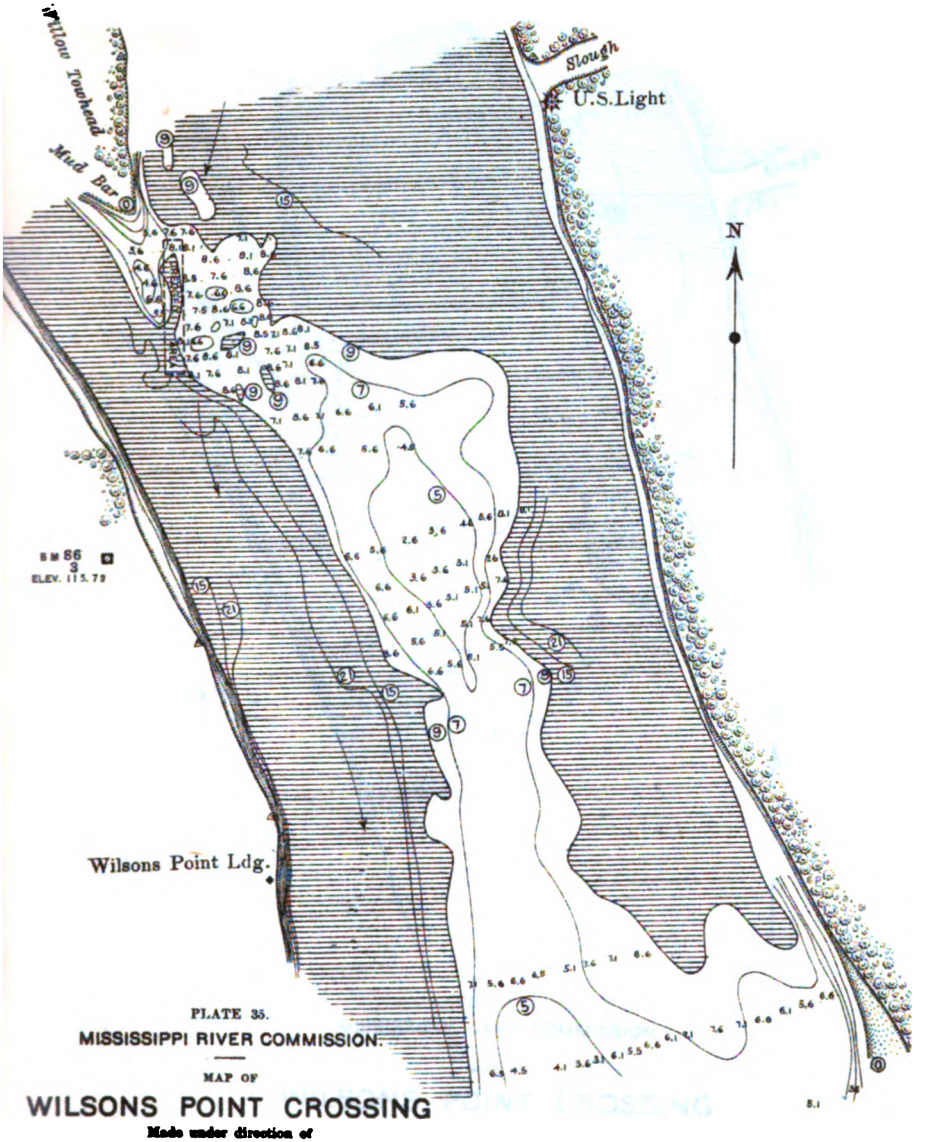

PLATE 35.

MISSISSIPPI RIVER COMMISSION.

MAP OF

WILSONS POINT CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of October 7, 1926.

AFTER DREDGING.

SCALE OF FEET.

1000 500 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet
1 indicate depths below mean low water, on the Lake Providence gage,
ich corresponds to a reading of 2.1 feet.
Gage at time of survey was 9.5 feet, or 7.4 feet above mean low water.
Shaded areas indicate depths below 9 feet at mean low water.
Dotted areas indicate bars above mean low water.

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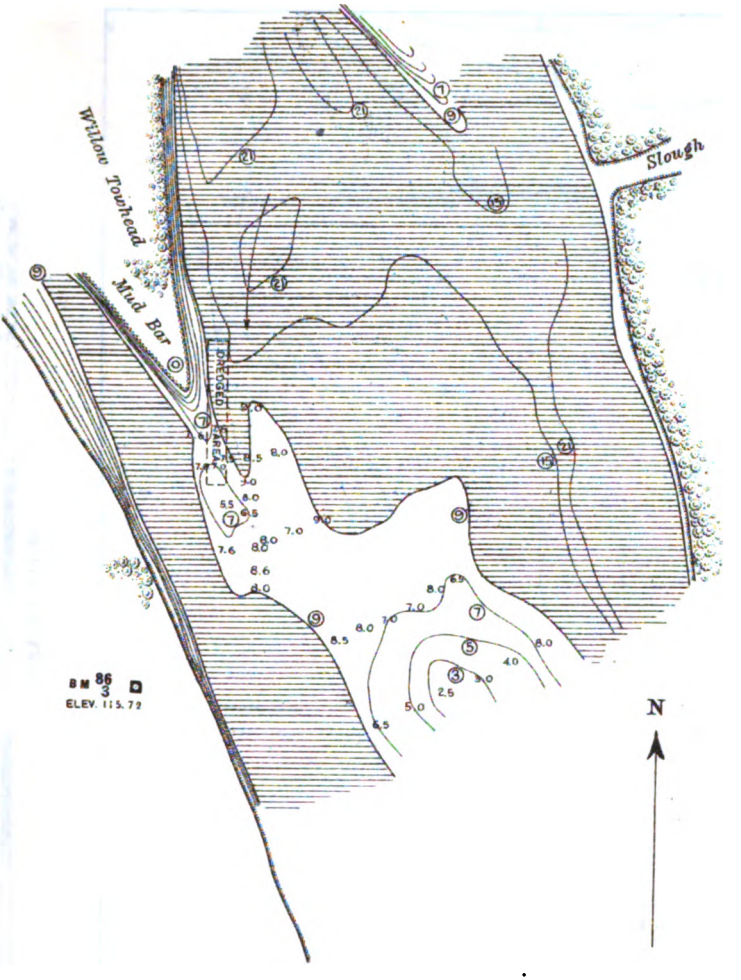

PLATE 36.

MISSISSIPPI RIVER COMMISSION.

MAP OF

WILSONS POINT CROSSING

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

Survey of November 27, 1896.

FIFTY DAYS AFTER DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water, on the Lake Providence gage, which corresponds to a reading of 2.1 feet.

Gage at time of survey was 14.35 feet, or 12.25 feet above mean low water.

Shaded areas indicate depths below 9 feet at mean low water.

Dotted areas indicate bars above mean low water.

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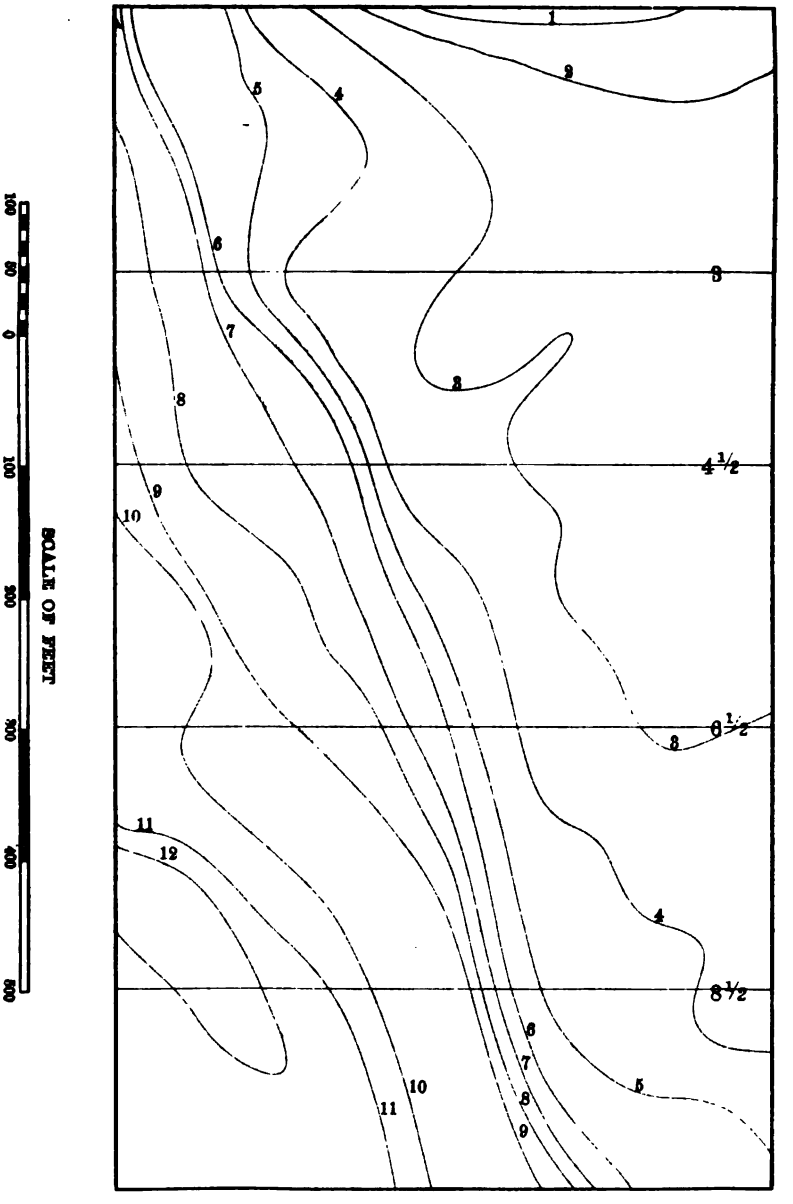

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PLATE 37.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PART OF COW ISLAND BAR

BEFORE TEST OF DREDGE GAMMA,

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

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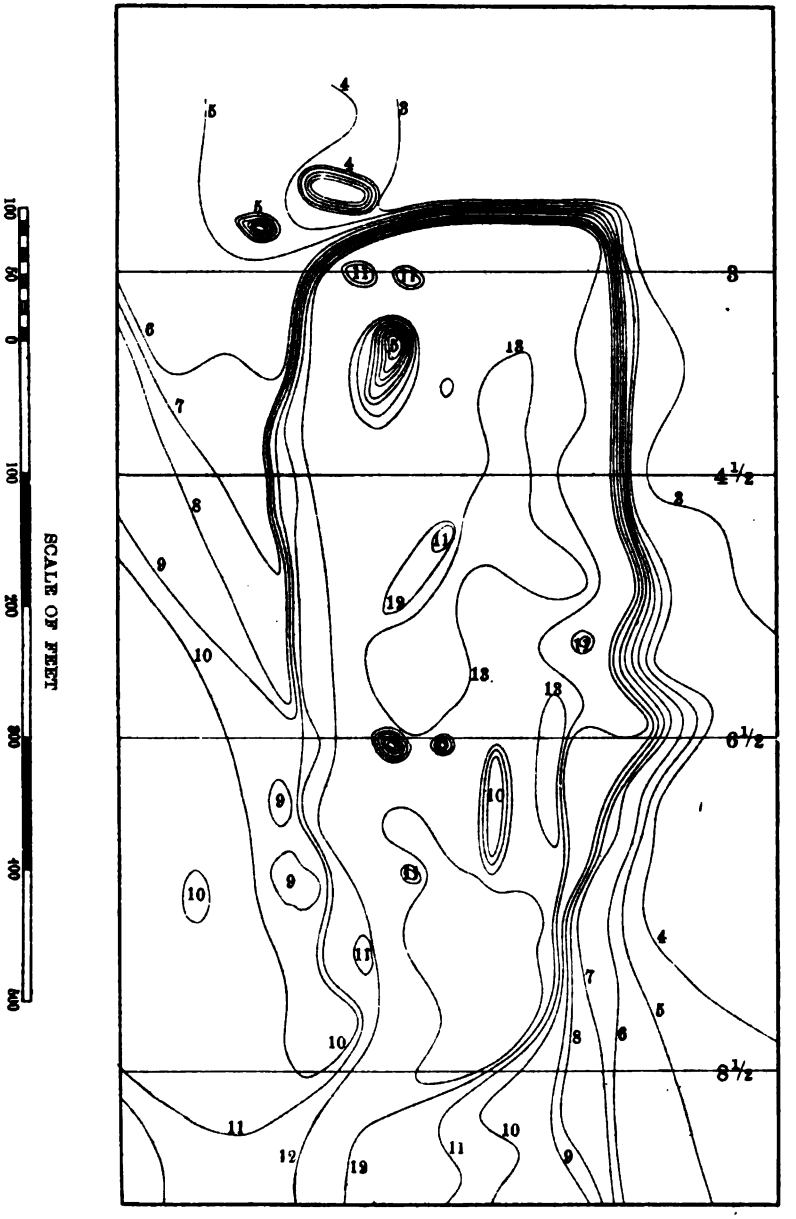

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PLATE 38.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PART OF COW ISLAND BAR

AFTER TEST OF DREDGE GAMMA,

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

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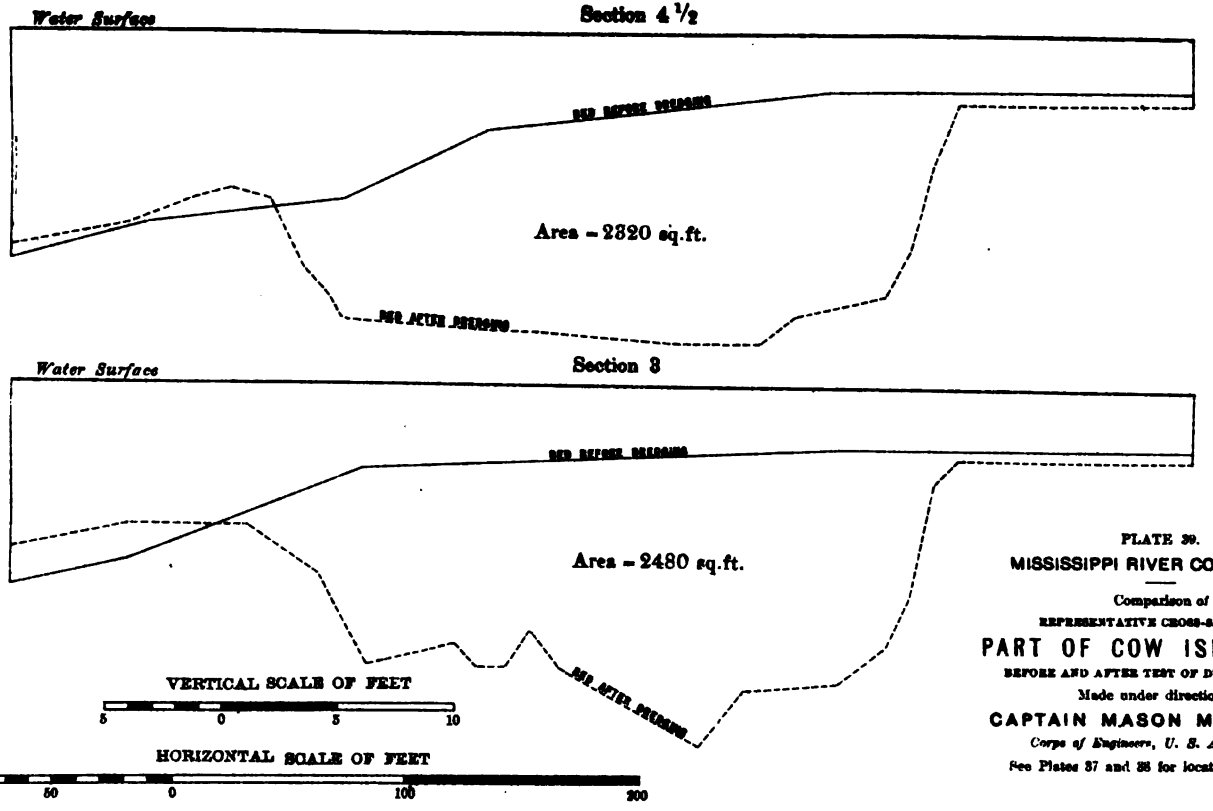

PLATE 39.

MISSISSIPPI RIVER COMMISSION.

Comparison of

REPRESENTATIVE CROSS-SECTIONS OF

PART OF COW ISLAND BAR

BEFORE AND AFTER TEST OF DREDGE GAMMA,

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

See Plates 37 and 38 for location of sections.

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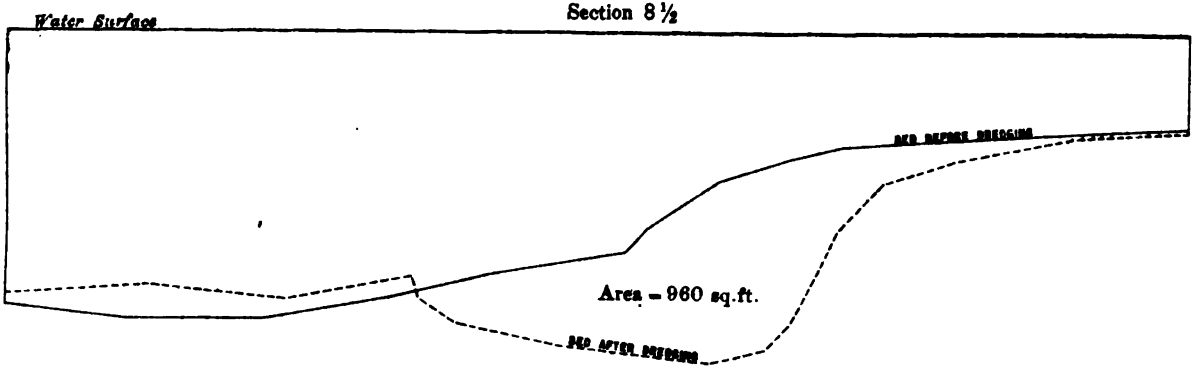

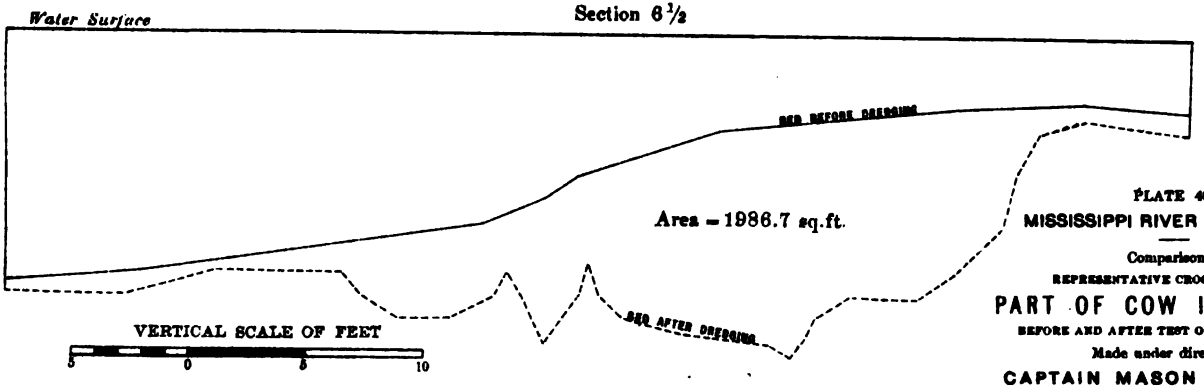

VERTICAL SCALE OF FEET

5 0 5 10

HORIZONTAL SCALE OF FEET

100 50 0 100 200

PLATE 40

MISSISSIPPI RIVER COMMISSION.

Comparison of

REPRESENTATIVE CROSS-SECTIONS OF

PART OF COW ISLAND BAR

BEFORE AND AFTER TEST OF DREDGE GAMMA,

Made under direction of

CAPTAIN MASON M. PATRICK,

Corps of Engineers, U. S. A., Secretary.

See Plates 37 and 38 for location of sections.

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TABLE NO. 13.—*Abstract of expenditures, United States dredging fleet, from May 1, 1898, to April 30, 1899.*

Care of plant		$21,781.99
Repairs to plant:		
Dredge—		
Alpha	$3,461.73	
Gamma	3,382.76	
Delta	6,847.50	
Epsilon	5,429.24	
Zeta	5,255.84	
Steamer—		
Minnetonka	88.58	
Mississippi	51.00	
Patrol	253.93	
Search	135.75	
Vidalia	65.03	
Vulcan	769.70	
Quarterboat No. 13	220.21	
Quarterboat *Illinois*	693.61	
Barges	1,233.12	
Skiffs	26.51	
Pile sinkers	680.25	
		28,588.76
Constructing plant:		
Pile Sinker No.—		
981	627.60	
982	759.38	
983	740.97	
984	447.08	
Dredge *Beta*	32,499.75	
Steamer *Minnetonka*	13,939.05	
		49,013.78
Testing dredge *Alpha* [1]		640.47
Field operations, dredging:		
Dredge—		
Alpha	11,650.02	
Gamma	20,608.57	
Delta	17,473.80	
Epsilon	24,105.40	
Zeta	18,215.10	
Inspection	14,769.14	
Surveys	13,450.78	
		120,272.76
Tools and appliances		22,051.23
Total		242,348.99

TABLE NO. 14.—*Summary of capacity tests of dredges.*

	Dredge Gamma, Cow Island Bar, Oct. 31 to Nov. 3, 1898.	Dredge Delta, in pocket behind Towhead of Island 18, Oct. 30 to Nov. 2, 1898.	Dredge Epsilon, in pocket at foot of Phillips Towhead, Nov. 26 to Nov. 28, 1898.	Dredge Zeta, Cherokee Bar, Nov. 3 to Nov. 6, 1898.
Extreme width of suction ..... feet..	19	33.6	20.3	20.8
Number of cuts made	3	4	4	6
Total length of cuts ..... feet..	4,566	2,711	2,015	1,785
Time actually dredging ..... hours..	45.50	27.38	24.93	62.92
Average advance per hour ..... feet..	100.3	99.0	81.0	28.4
Average depth of suction below water surface..do...	15	13.6	17	17
Average depth of cut ..... do...	7.16	6.55	9.6	20.6
Average steam pressure	145.6	151.1	180	146.8
Average speed of main pump..revolutions per min..	150	140.9	178	179.0
Average speed of jet pump ..... do...	184.5	.....	207	225.4
Suction head, main pump ..... feet of water..	8.6	16.3	9.8	10.5
Delivery head ..... do...	11.0	34.5	34.6	22.0
Jet discharge head ..... do...	25.9	.....	25.3	24.9
Total number of cubic yards moved	45,856	34,462	32,407	40,991
Average number of cubic yards per hour	1,008	1,259	1,305	652
Cost per linear foot for time actually dredging	$0.0898	$0.0926	$0.142	$0.307
Cost per cubic yard for time actually dredging	$0.0089	$0.0073	$0.0092	$0.0134
Length of discharge pipe ..... feet..	750	1,000	1,000	250 to 600

[1] Tests made in May and June, 1898.

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APPENDIX 2.

REPORT OF CAPT. E. EVELETH WINSLOW, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST AND SECOND DISTRICTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 20, 1899.

COLONEL: I have the honor to submit the following report of operations in the First and Second districts for the year ending April 30, 1899. The work in these districts was in charge of Capt. Mason M. Patrick, Corps of Engineers, until relieved by me December 5, 1898.

FIRST DISTRICT (Cairo to foot of Island No. 40, 220 miles).

Columbus, Ky. (*21 miles below Cairo, L.*).—In 1889 and 1890 five spur dikes of brush and stone were built along a caving bank in front of this place; these protected 2,200 linear feet of bank. This work at present is in fair condition, and has accomplished the object for which designed. Some caving has occurred in recent years between the dikes where the bank was unprotected. No additional work is required at present.

Hickman, Ky. (*26 miles below Cairo, L.*).—In 1889 a mattress of brush and stone, 930 feet long, was placed along the bank in front of this town. This was repaired at various times, and the work extended downstream 630 feet, making the total length of revetment now in place 1,560 feet. No further work is required at present.

New Madrid, Mo. (*71 miles below Cairo, R.*).—The bank here had been rapidly caving for many years. In 1893 the bank along the upper portion of the town was protected by 900 feet of fascine mattress 250 feet wide, and the upper bank paved. Seven hundred linear feet of similar work was placed below this in 1894, and 500 feet more in 1896. The sundry civil act of July 1, 1898, appropriated $50,000 for revetment of the bank at this place. With this amount it was proposed to continue the revetment downstream for about 1,200 feet, and also to make a slight extension to the revetment at the head of the work. Work was begun September 18 and completed December 2. One thousand two hundred and eighteen feet of revetment were constructed below existing work and 355 feet above, all work being of the standard type, with fascine mattress 250 feet wide and paved upper bank. The total length of revetment at this place is now about 3,650 feet, and is all in good condition. The entire front of the town is now amply protected, but the bank below is caving rapidly. (For details of the work see report of Assistant Engineer Nolty.)

Forty thousand dollars has been appropriated by the sundry civil act of March 3, 1899, for completing revetment work at New Madrid.

Caruthersville, Mo. (*110 miles below Cairo, R.*).—The sundry civil act of July 1, 1898, appropriated $20,000 to be used in protecting the bank at and near the town of Caruthersville, Mo. The bank here has been caving quite rapidly since 1897, beginning a short distance above the town and increasing downstream to a maximum in the bend about half a mile below the town. The appropriation being insufficient to protect the entire front of the town by a continuous revetment, it was proposed to construct with it four brush and pole crib dikes similar to those successfully used in the Memphis Harbor, the dikes being placed about 450 feet apart, center to center, and having a standard mattress foundation 120 feet by 250 feet wide. This project, having been unavoidably delayed, did not receive the approval of the Secretary of War until November 15, and work therefore could not be begun until November 28. The mattresses for three of these dikes were completed without incident, but running ice caused a stoppage of work for four days during the construction of the fourth mattress. Work was begun on the crib of Dike 4, and after another four days' delay from ice and drift the lower section was completed and launched January 6. Work was then suspended on account of a rapid rise in the river, accompanied by heavy drift and ice. In fact, the entire work was carried on under the most unfavorable conditions of weather, river stage, and running drift and ice, the latter causing some damage to plant. (For details of work see report of Assistant Engineer Nolty.)

Present conditions.—The four mattresses are complete and in place, the bank for the cribs has been graded and partly paved, and the crib of Dike 4 is half completed. During the high water this spring extensive caving took place below the fourth dike. The extent of this damage, and whether or not it affects the work in place, can not at this date be determined, as the river has not yet fallen low enough to permit an examination.

Thirty-five thousand dollars have been appropriated by the sundry civil act of March 3, 1899, for rectifying the bank at and near Caruthersville.

Plum Point Reach (*147 to 186 miles below Cairo*).—The works of improvement in this reach have extended from Daniels Point to Craighead Point, Arkansas, a distance of about 20 miles. The operations have been fully described in previous reports. In

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general terms, the work done has been the protection of caving banks by the construction of 67,400 linear feet of revetment now in place, the closure of Gold Dust Chute by means of pile dikes and a brush and stone dam, and the closure of Osceola and Bullerton chutes by means of pile dikes. The result of these works has been to give an increase in depth over the crossings in Plum Point Reach during extreme low-water stages. Of the funds made available by the sundry civil act of July 1, 1898, the commission allotted to this reach $40,000, which it was proposed to expend at the following points:

About $7,500 at Ashport Bend, repairing old revetment.
About $16,000 at Fletchers Bend, extending revetment.
About $6,000 at Osceola Bar, protecting head of bar.
About $6,500 at Gold Dust Dam, repairs.
About $4,000, contingencies and slight repairs to other works of the reach.

Ashport Bend.—The revetment work in this bend was begun in 1882 and continued in 1891–1894. The total length of bank revetted is about 16,600 feet, of which work all but 1,800 feet is of the old type of mattress. After the subsidence of the flood of 1898 it was found that five faults had developed in this work—three in the upper bank work above the limit of paving and two at the junction of the mattress work with the bank paving. Repair work was begun January 10, 1899, on the construction of a pocket mat for the largest fault, which was completed and sunk under difficulties. The rapidly rising river, with heavy drift, caused a suspension of work at this point for the season.

Fletchers Bend.—This has been for many years one of the worst caving places in the river. Some revetment work was done here in 1884 and 1885. This was of the old-style work and nearly all of it has since been destroyed. Work was resumed in 1888 and continued at intervals until 1896, extending to near New Haven Landing. Since 1896 the caving has attacked the bank actively at and above the head of the existing work and has destroyed about 1,500 feet of it. To prevent or delay a further destruction of this work it was proposed to construct at the head of the existing work a brush and stone spur, resting on a standard fascine mattress. Work was commenced November 5 and continued until stopped, November 22, by a rise in the river, accompanied by a strong current and heavy drift. The river having receded, work was resumed December 20 and completed January 9.

Osceola Bar.—The flood of 1898 did some damage to the revetment work at this point in three places; in all, about 800 feet of upper-bank protection being destroyed. The river mats all appeared to be in good condition, the trouble coming from faults at the junction of these with the bank paving. This damage was repaired by the construction of connecting mats and repaving the bank. At the head of the bar there was a very large washout just at the upper edge of the work. A sill mat and crib were placed across this washout to prevent its enlargemnt.

Work on Gold Dust Dam and other points in the reach was prevented by the stage of water and short working season. (For details of the work in Plum Point Reach see report of Assistant Engineer Nolty.)

Present condition.—At this date the river has not fallen low enough for an examination, so it can not be stated whether any new faults have developed in this reach.

From the funds made available by the sundry civil act of March 3, 1899, the commission has allotted $60,000 to Plum Point Reach, to be distributed as follows:

Daniels Point, repairs to revetment	$15,000
Fletchers Bend, revetment work	25,000
Gold Dust Dam, repairs	10,000
General repairs and contingencies	10,000

Experimental dikes.—The commission allotted out of the funds made available by the sundry civil act of July 1, 1898, $25,000 for the construction of dikes at low-water bars, under the supervision of the subcommittee of the committee on construction. The bar decided on for the first work was that opposite Point Pleasant, Mo. (80 R.). The location of these dikes and their character are shown on drawings accompanying this report. Work on Dike No. 1 was begun October 20. After the first section, 240 feet long, of this was completed it was necessary on account of the high stage of river and deep water at location of anchor piles to temporarily suspend work on this dike and to construct Dike No. 3, which was located in shoaler water. This dike was completed to a length of about 982 feet, and a small crib was built at its inshore end to prevent cutting at this point. The river in the meantime had continued to rise, and work was suspended till more favorable conditions. On January 6 work was resumed under more favorable conditions and the second section of Dike No. 1 was completed. During this work another rapid rise occurred and work was suspended for the season. Each section of dike was 20 feet wide at bottom and from 9 to 15 feet high to end of screen poles, depending on depth, so as to have the end of poles near the low-water line. (The details of construction will be found in the report of Assistant Engineer Nolty.)

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In accordance with a resolution of the commission, adopted at its March session, this work has been transferred to the office of the secretary of the commission.

LEVEES.

Upper St. Francis Levee district (35 miles above to 70 miles below Cairo, R.).—This district extends from Commerce, Mo., to New Madrid, Mo., a distance by river of about 105 miles. The length of levee line when completed will probably be about 80 miles. The area protected is the land between the river and Prairie Ridge, which is cut by the river at New Madrid. This area is about 700 square miles. This land, though generally low, is separated into sections by ridges generally above overflow. In addition to the above, a very large area of the Lower St. Francis Bottom is subject to overflow from this same water, as it can find its way through the low gap at the upper end of Prairie Ridge. This latter region is also subject to overflow by high water getting through the narrow gap between Cape Girardeau and Commerce Ridge, but a small State levee has been built across this gap. A levee has been built by local authorities from Commerce to the Iron Mountain Railroad, a mile above Birds Point, and is in good condition. From Birds Point southward a levee was started in 1896, but lack of funds caused the cessation of work after about 3 miles had been worked on, but practically none of this was completed. There is no data in this office from which to calculate the amount of earth in the existing levee from Commerce to Birds Point, or the total yardage necessary to close in this basin. To close the gap at Birds Point and complete the levee as far down as O'Briens Ridge (12 miles) will require about 850,000 cubic yards. No work has up to the present time been done in this district by the United States, but out of the funds made available by the sundry civil act of March 3, 1899, the commission has allotted the sum of $20,000 for work at and below Birds Point.

Lower St. Francis Levee district (80 to 298 miles below Cairo, R.).—The length of this district by river is 218 miles. The length by the levee line when completed will probably be about 215 miles. The length of completed levee is now about 122¼ miles, beginning 1 mile above Point Pleasant, Mo. (80 R.) and ending back of Centennial Island (208 R.). Near Walnut Bend, Ark. (275 R.) there is a levee line 6 miles long which will form part of the proposed continuous line to the mouth of the St. Francis River (298 R.). Including this Walnut Bend line, 128¼ miles of levee are now in place, leaving to be constructed for the complete closing of this basin about 86¼ miles. The area that will probably be protected by the completed levee will be about 3,490 square miles. At the date of the last Annual Report one contract was in force, that of Shippey & Johnsen, for repairs to Walnut Bend levee, at 15.99 cents per yard. This contract was satisfactorily completed by December 1, 1898. From the funds made available by the sundry civil act of July 1, 1898, the commission allotted the sum of $34,000 for levee work in this district. This was used in work at the following points: A new loop at Rankins mill, Mo. (103 R.); repair, enlargement, and topping near Caruthersville, Mo. (109 to 113 R.); repairs, enlargement, and topping near Tylers, Mo. (125 to 128 R.); repairs, enlargement, and topping near Cheeks, Ark. (131 to 135 R.); spur at Rosa, Ark. (157 R.); repairs near Luxora, Ark. (160 R.); repair, enlargement, and topping near Sans Souci, Ark. (166 to 177 R.); repairs, enlargement, and topping near Nodena, Ark. (180 to 187 R.). In addition to the above work by the United States the St. Francis levee board has repaired 10 miles of existing levee and constructed about one-fourth of a mile; this last across the chute of Island No. 38 (208 R.).

During the period from May 1, 1898, to April 30, 1899, there were constructed as follows:

	Cubic yards.
By the United States	218,537
By the St. Francis levee board	151,947
Total	370,484

During the same period the United States expended the sum of $38,060.15. This includes office expenses, superintendence, engineering expenses, and contingencies. The average cost, including above items, was 17.4 cents per yard.

The following is a summary of the levees in this district:

	Cubic yards.
Constructed by United States and in place April 30, 1898	3,014,810
Added from May 1, 1898, to April 30, 1899	218,537
Total in place April 30, 1899	3,233,347
Constructed by levee boards and citizens and in place April 30, 1898	4,024,614
Added from May 1, 1898, to April 30, 1899	151,947
Total in place April 30, 1899	4,176,561

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Aggregate:	Cubic yards.
Erected by the United States	3,233,347
Erected by others	4,176,561
Total effective in place April 30, 1899	7,409,908

On April 30, 1899, one contract is still in force, with T. Mike, for enlargement work near Tylers, Mo. It is expected that this contract will be completed by July 1, 1899.

The high water of the year was not sufficient to threaten the levee at all; no breaks occurred, and the only damage was a small amount of wave wash in recent work where the sodding had not taken hold. No expense was incurred in watching or nursing the levee during high water. There are two existing breaks in the line, one at the town of Point Pleasant, about 1,000 feet long; money was available to close this gap, but it was impossible to obtain the right of way, as the citizens take but little interest in the work. No water passed through this gap this season. The other gap is at Stancils Bayou. This is due to a cut made in the levee last summer for the purpose of draining off back water. The persons who cut the levee failed to close it, as it was expected they would, and all the pressure brought upon them to make them do it failed, and the levee is still open. The guilty parties were, however, indicted and tried in April under the law for the protection of levees, but their sentence has been suspended for the present. Some water ran through this break this year and about 20 square miles were inundated. Of this but a small part is cleared and that principally land belonging to those who cut the levee.

To enlarge the existing levees and raise them to the final grade, as established by the commission, will require the putting in place of about 4,000,000 cubic yards of earth. No accurate surveys have been made for the location of the portion of the line not yet constructed, but it is roughly estimated that this will require about 11,000,000 cubic yards, in addition to the above.

From the funds made available by the sundry civil act of March 3, 1899, the commission has allotted the sum of $123,500 for levee work in this district. In addition, the St. Francis levee board has funds at its command, and has let contracts for building 24 miles of levee from the present terminus to below the city of Memphis and for extending the Walnut Bend levee upstream 11 miles. This will leave a gap of about 50 miles still open. A profile accompanying this report shows in detail the grades of the levee line and the locality of work done in this district during the period covered by this report.

SECOND DISTRICT (FOOT OF ISLAND NO. 40 TO MOUTH OF WHITE RIVER, 180 MILES).

Hopefield Bend (227–230 miles below Cairo, R.).—The revetment in this bend, now about 16,000 feet long, extends from Mound City Landing to Hopefield Point; it was begun in 1882 and completed in 1888. From 1890 to 1893 extensive repairs were made along the lower 10,000 feet by placing wider river mats and revetting the upper bank with stone. The work along this lower 10,000 feet was failing, on account of its narrow width and generally weak design. The high water of 1897 damaged this work by scouring above and behind the bank paving. This damage was repaired in the fall of the same year by crib dikes, built across the pockets excavated by the flood. The high water of 1898 seriously damaged the revetment at several places. This consisted of holes scoured out at the junction of mat and bank work, undermining the bank paving and extending under the inshore edge of the river mat. Repairs were made, beginning October 31 and ending November 19. New mats of the fascine type were sunk in the pockets made by the scour. The slope was restored by cribs and the bank repaved. (For details see report of Assistant Engineer Rees.)

It is absolutely essential for the existence of the harbor of Memphis that this point should not be allowed to recede further. There are at present a few weak points which should be attended to.

From the funds made available by the sundry civil act of March 3, 1899, the commission has allotted the sum of $60,000 for repairs to the revetment work at Hopefield Bend.

Memphis Harbor (230 miles below Cairo, L.).—The bank for a length of 10,166 linear feet has been revetted by the United States and for 2,206 linear feet by a system of dikes built by United States employees from funds supplied by the citizens. Most of the work placed has held without loss. Along the upper portion of the harbor front, extending from Wolf River to below Monroe street, a large sand bar has formed. This has made the compress, elevator, and oil mills situated above the paved levee inaccessible to steamboats, and the tailing down of the sand bar along the paved steamboat landing has shut off about one-half of it, or 1,500 feet, to steamboat use during low stages of the river. At the date of the last Annual Report there remained an unprotected portion of the bank 1,200 feet long between the lower end of the Government revetment and the bridge company's revetment. The sundry civil act of July 1, 1898, appropriated $35,000 for the completion of the revetment along the bluff and $10,000 for repairing the damage done to previous revetment

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work by the flood of 1897. With the former it was proposed to revet the gap of about 1,200 feet with a revetment of standard type, the fascine mattress being about 300 feet wide and shore paving extending to the 22-foot stage. Work was begun September 14 and the project was completed November 14. (For details see report of Assistant Engineer Rees.) This now makes the revetment work along this front complete from Wolf River to below the bridge, a total distance of about 12,400 feet, all of which is in good condition. No appropriation or allotment has been made for work at this point, but the last river and harbor act directs the commission to examine into the advisability and cost of removing the sand bar formed in front of the landing.

Wolf River (230 miles below Cairo, L.).—The width of the bar in front of Wolf River at low stages is about 2,100 feet; through this the river has formed a fairly fixed channel to its junction with the Mississippi. The river and harbor act of June 3, 1896, made available for the improvement of this stream the sum of $35,000. The approved project provided for dredging and the removal of sunken logs, snags, and other obstructions. An attempt was made to have this work done by contract, but during the progress of the work so many unexpected difficulties presented themselves that justice to the contractor required the termination of the contract, which was done May, 1898, after about 30,000 yards of material had been removed.

In July, 1898, a dipper dredge was purchased for use on this work and operations were subsequently carried on by hired labor. Work was begun July 22 above the railroad bridge and continued until August 13, when stopped by a rise of the river. Work was resumed August 31 near the mouth and continued until November 7; again resumed on the 14th above the bridge and stopped for the season November 29. A total of about 28,000 yards was removed from the channel at a cost of about 8 cents per yard. In addition, about 90 snags and logs were removed from the channel by the dredge, aided at times by dynamite. (For details of this work see report of Assistant Engineer Rees.) Since the stoppage of actual work some slight modifications, shown necessary by the last season's work, have been made to the dredge.

As during the high water in the Mississippi there was slack water in Wolf River, a fill has undoubtedly taken place in the latter which its current is powerless to remove. There is, however, about $20,000 remaining of the appropriation which will be used to remove the deposit when the water falls low enough.

Nonconnah Rock (236 miles below Cairo).—This obstruction, consisting of a ferruginous sandstone and cemented gravel, is about 4 miles below the Memphis Bridge, and about 700 feet from the Tennessee shore. It has been a source of annoyance to boats with heavy tows, owing to its location directly in the channel. The removal of this rock was begun in 1893 under contract. Later the work was undertaken by the United States with a plant constructed for the purpose. Very effective work was done, and 2,333 cubic yards were removed at the small cost of $1.88 per cubic yard. From funds made available by the sundry civil act of July 1, 1898, the commission allotted $3,000 for the continuation of this work. Work was begun September 15 and completed November 18. Two thousand three hundred and fourteen cubic yards of rock were destroyed, covering an area of 25,000 square feet. There is now a least depth of 7 feet over the rock at the zero stage of the Memphis gauge. (For details see report of Assistant Engineer Le Vasseur.) This work is considered completed.

Helena Harbor (306 miles below Cairo, R.).—Six hundred linear feet of continuous revetment and five spur dikes were built in 1889, protecting about 3,000 feet of bank along the city front. The lower dikes being in an unfinished condition, the bank caved badly in their immediate vicinity. This revetment was further extended to a total length of 4,100 feet in 1896. The sundry civil act of July 1, 1898, appropriated $30,000 for the completion of the revetment at Helena. With this it was proposed to extend existing work downstream and repair, where necessary, existing work. Work was begun November 16 and completed January 11. The revetment was continued downstream 926 feet, the fascine subaqueous mat being 250 feet wide. The bank paving was carried up to about 18 feet on the Helena gauge, where a depression in the bank existed, and across this two small dikes were built reaching to the top of the bank. In addition, repairs were made to 1889 work. The intermediate spaces between dikes were mattressed below low water, and two small dikes were built above the water line so as to restore the normal slope of the bank. (For details of this work see report of Assistant Engineer Rees.)

Thirty thousand dollars have been appropriated by the sundry civil act of March 3, 1899, for improving harbor and rectifying the banks at Helena.

LEVEES.

Upper Yazoo Levee district (244 to 365 miles below Cairo, L.).—The length of this district by river is 121 miles, and the length of levee lines 123.88 miles. The territory protected by the levee is 3,281 square miles. At the date of the last annual

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report one contract was in force, with Reese Thomas, sections 77–79 (330 L.) at 16.99 cents per cubic yard. This contract was satisfactorily completed November 1, 1898. From the funds made available by the sundry civil act of July 1, 1898, the commission allotted $46,000 for levee work in this district. With this a new loop was constructed on sections 81–82 (332 L.). The local board during this period has repaired and enlarged 24 miles and topped 4 miles of existing levee. The work done between May 1, 1898, and April 30, 1899, was as follows:

	Cubic yards.
By the United States	484,255
By the local levee board	594,860
Total in place April 30, 1899	1,079,115

The United States expended in this district for levee construction between May 1, 1898, and April 30, 1899, the sum of $77,370.54. This includes office expenses, superintendence, engineering expenses, and contingencies. The average cost per cubic yard of the work done, including the above items, was 15.98 cents.

The following is a summary of the levees in this district:

	Cubic yards.
Constructed by United States and in place April 30, 1898	4,415,261
Added by United States from May 1, 1898, to April 30, 1899	484,255
Total in place April 30, 1899	4,899,516
Constructed by levee board and in place April 30, 1898	10,266,905
Added by levee board May 1, 1898, to April 30, 1899	594,860
Total in place April 30, 1899	10,861,765
Levees in place April 30, 1899:	
Erected by United States	4,899,516
Erected by local levee board	10,861,765
Total in place	15,761,281

On April 30, 1899, one contract is still in force with Aderholdt & Lowrance for work on sections 81–82 at 14.94 cents per cubic yard. It is expected that this contract will be completed by July 1, 1899. The high water of this season was not sufficient to threaten the levee, and no damage beyond some slight wave wash was caused. No expense was incurred in protecting the levee during this high water.

The estimated yardage required to raise and enlarge this levee line to the final grade established by the commission is approximately 18,000.000 cubic yards.

From the funds made available by the sundry civil act of March 3, 1899, the commission has allotted $123,500 for levee work in this district during the coming season.

A profile accompanying this report shows in detail the grades of the levee line and the locality of work done in this district during the period covered by this report.

White River Levee district (306 to 385 miles below Cairo, R.).—The length of this district by river is 79 miles, and by the levee line 74 miles. The levee starts at the foot of Crowleys Ridge, at the upper end of the city of Helena, and the terminus is at the end of the back line of the Laconia Circle Levee, which doubles on itself and joins the main line at Laconia (375 R.). The United States has control of 64 miles of the levee, the remaining 10 miles of levee being maintained and controlled by the local boards, 8 of these miles consisting of the back line of the Laconia Circle and the other 2 being in front of the city of Helena. The territory to be protected is a narrow strip of from 8 to 30 miles in width, lying between the Mississippi and White rivers, and having an area of about 910 square miles. Four breaks exist at present in this line, all made by the flood of 1897. The total length of existing breaks is about 10,000 feet, and all are situated within a distance of 4 miles near Modoc and Hugheys (337 and 340 R.).

At the date of the last annual report one contract was in force with the J. S. McTighe Company for work at Schoolhouse Bayou (342 R.). This contract was satisfactorily completed November 30, 1898.

From the funds made available by the sundry civil act of July 1, 1898, the commission allotted for levee work in this district the sum of $30,000. With this work has been done as follows: Repair, enlargement, topping, and banquet near Westover (310–321 R.); repair, enlargement, and topping in and near Zenor Bend (343–370 R.); also slight repairs of damage done by high water of 1898. The local levee boards have also during this period put in place about 24,000 yards in the Helena Front Levee.

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The work done between May 1, 1898, and April 30, 1899, is as follows:

	Cubic yards.
By the United States	194,254
By local levee board and others	24,200
Total in place April 30, 1899	218,454

The United States expended in this district for levee construction between May 1, 1898, and April 30, 1899, the sum of $41,061.18. This includes office expenses, superintendence, engineering expenses, and contingencies. The average cost per cubic yard of the work done, including the above items, was 19.60 cents. The sum of $3,000 of the above was expended in a complete survey of this line during February and March, 1899.

The following is a summary of the levees in this district:

	Cubic yards.
Constructed by United States and in place April 30, 1898	5,337,478
Added by United States May 1, 1898, to April 30, 1899	194,254
Total in place April 30, 1899	5,531,732
Constructed by levee boards and in place April 30, 1898	1,018,866
Added by levee boards May 1, 1898, to April 30, 1899	24,200
Total in place April 30, 1899	1,043,066
Effective levees in place in this district April 30, 1899:	
Erected by United States	5,531,732
Erected by levee boards and others	1,043,066
Total	6,574,798

On April 30, 1899, one contract is still in force in this district, with Martin Jennings & Co., for enlargement work on levee back of Zenor Bend. It is expected that this contract will be completed by August 1, 1899.

The levee in this district is generally low and weak. Much of it is below the high water of 1897. To bring it up to the final grade established by the commission will require that it be raised from 3 to 7 feet, besides banquets will be needed where the levee exceeds 12 feet in height. To do this and to close the existing breaks will require the placing of not less than 6,000,000 cubic yards. The recent high water was not sufficient to really test the levee. But little damage was done, consisting of wave wash in a few places where the sod had not taken hold. A total expense of $109 was incurred in preventing damage from this cause.

From the funds made available by the sundry civil act of March 3, 1899, the commission allotted $61,750 for levee work in this district during the coming season.

A profile accompanying this report shows in detail the grades of the levee line and the locality of work done in this district during the period covered by this report.

GENERAL REMARKS ON LEVEE WORK IN ALL THREE LEVEE DISTRICTS.

All levee work, though pushed as vigorously as possible, has been much delayed, and in no one of the districts were all the contracts completed. The delay was caused, first, by the lateness of the passage of the act and of the allotments. The allotments not being made until late in June, it was impossible to enter into contract before the last of August. A further delay was caused by the presence of yellow fever in the Mississippi Valley and the consequent quarantine restrictions and scarcity of labor. Later in the season the weather became most unfavorable; heavy rains and unprecedentedly cold weather caused still longer delays. Fortunately the water this spring did not reach a really dangerous stage, and no trouble has occurred from uncompleted levee work.

STAGES OF THE RIVER DURING THE YEAR, AND VARIOUS GAUGE RECORDS IN THE FIRST AND SECOND DISTRICTS.

During the past year the river was neither very low nor very high.

At the date of the last Annual Report the flood of 1898 was subsiding. This fall continued with slight temporary rises until the end of July, the stage getting as low as 12.5 feet at Cairo on July 27, and 7.7 feet at Memphis two days later. This was followed by a rise amounting to about 15 feet at Cairo and 11 feet at Memphis. The river then fell, and for the remainder of the calendar year continued fairly low. The river, however, was at no time really low, the minimum gauge readings being at Cairo, 7.6 feet; New Madrid, 6.5 feet; Fulton, 6.6 feet; Memphis, 4.8 feet; Helena,

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7.8 feet, all about October 10. In January a rapid rise occurred, followed by a slight fall, which was succeeded by the flood of the year, which at the time of this report is slowly subsiding. This high water is far below the record, but is noticeable for the long period at which it continued practically at a stand. At Cairo the river remained between 45.8 and 46.2 feet (the maximum) from March 20 to April 9, a period of twenty days. At New Madrid the stage was 36 feet, maintained within one-tenth of a foot from March 21 to April 10. At Fulton the maximum was 34.9 feet and at Memphis 35.2 feet. The river at this point stood above 35 feet from March 26 to April 14. At Helena, owing to the effect of the still open St. Francis Bottom, the rise was much slower and the top not so prolonged; the maximum of 46.9 feet was reached about April 13. The failure of the river to reach the ordinary low stage and the frequent temporary rises during the working season seriously interfered with revetment and channel work in these districts, increased the cost of the work done, and prevented the entire programme of operations from being completed.

OVERFLOW FROM HIGH WATER.

During the last high water the conditions of overflow were about as follows:

Upper St. Francis Levee district.—The country above Birds Point was protected by the existing levee. The town itself is too high to be overflowed by the stage of water, but below the town the water came through various gaps in the levee and around the end of it and covered as much land as if the levee did not exist.

Lower St. Francis Levee district.—The water did not get high enough to go through the gap at the town of Point Pleasant. Water did, however, get through the cut at Stancils Bayou (94 R.) and overflowed some 20 square miles; most of which is low and swampy land not yet cleared. From the south end of the levee to the mouth of the St. Francis River the overflow was general, only the highest spots being above water. Some trouble was caused in this levee district by backwater in the Crooked Lake region, the levee crossing Crooked Lake Bayou (148 R.), the natural drainage of this country. The artificial drainage system provided by the local authorities became choked, and quite a large region was overflowed by backed-up rain water. The local levee board expects this season to dig drainage ditches, so as to prevent the recurrence of this overflow.

Upper Yazoo Levee district.—The levees in this district are intact, and no trouble was caused by overflow.

White River Levee district.—Through the breaks in this region, of which the total length is 10,000 feet, the water ran freely and overflowed practically all the land back of and below these breaks. A small section of cultivated land lying close to the levee and just north of the end of Laconia Loop was about all that was not covered. Observations were made in this district by Assistant Engineer Purvis of the height of the water at the crest of this season's rise, and this was compared with the height corresponding to the same gauge reading at Helena in 1897 before the breaks in the levee. The result of the comparison is as follows: At Helena and for some miles below the heights are the same. Then this season's height begins to fall below that of 1897, reaching the maximum difference of 2.6 feet at the first break. At the last break the difference was 1.9 feet. Below the last break the difference decreases and disappears as we near the lowest point in the levee. Following around the circle and going up the back line of the Circle Levee, the present season's water rises above that of 1897 to as much as 2 feet near where the back of the levee joins the main line. These observations show clearly the effect of these breaks on the high-water line outside the levee and the backwater heights inside.

SURVEYS, GAUGES, AND OBSERVATIONS.

During the time covered by this report the following examinations and surveys have been made.

July, 1898.—An examination and survey of the levee line from Birds Point, Mo., to O'Briens (12 miles by levee). This is part of the Upper St. Francis Levee district.

August, 1898.—Hydrographic survey in the vicinity of Island No. 34.

September, 1898.—Hydrographic survey at Caruthersville Front to determine the best method of expending appropriation for this point. Detailed survey of Memphis Front. Hydrographic survey of Nonconnah Rock, preliminary to beginning operations at this point. Hydrographic survey of Point Pleasant Reach, to determine location of spur dikes. Examination of portion of Wolf River preliminary to beginning operations.

November, 1898.—Final hydrographic survey of Nonconnah Rock.

December, 1898.—Hydrographic survey of Helena Harbor. Final hydrographic survey of part of Wolf River, after dredging. Survey of Memphis Reach.

February, 1899.—Survey of White River Levee district (74 miles). Mileposts were established and much useful information obtained.

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Minor examinations and surveys were made from time to time during the progress of work at the various points where active operations were in progress.

Of the funds made available by the sundry civil act of March 3, 1899, the commission has allotted the sum of $5,000 for surveys, gauges, and observations in the first and second districts during the coming year.

PLANT.

From the funds made available by the sundry civil act of July 1, 1898, the commission allotted $15,000 for care of and repairs to plant in the first and second districts.

Most of the plant which has been accumulated in these districts is now stored near Memphis, the floating property being tied to the bank a short distance below the bridge. This plant consists of steamboats, quarter boats, shop boats, graders, pile drivers, barges of all kinds, miscellaneous craft, machinery, and the necessary outfits for large working parties. There are now borne on my property return some 24,000 articles, the original cost of which was about $450,000. Much of this is in fair condition, but some of the articles have from use and deterioration reached a condition where extensive repairs are necessary. To put the plant in good working condition will require the expenditure of not less than $50,000.

During the year the most important work on plant was on the steamer *Titan*. This vessel, while towing, was snagged and sunk on a sand bar August 25. The falling river left the vessel high and dry. An examination showed a hole in the bottom 48 feet long. This was temporarily repaired and the vessel floated off December 29. As extensive repairs were necessary, authority was obtained and a contract entered into for these repairs. The vessel is now on the ways at St. Louis. During a squall on the night of July 31 the *Itasca* was swamped and sunk. It was subsequently raised and the damages repaired. The dredge *Wolf* is now undergoing alterations shown to be desirable by last season's operations. The floating dock has been in service without any but the slightest repairs since 1889. It needs thorough overhauling, calking, and a partly new bottom. This is now being done.

In addition to the above, minor repairs were made to steamers *Chisca*, *Graham*, and *Abbot*, barges, graders, and other plant. (For details see report of Assistant Engineer Nolty.)

Of the funds made available by the sundry civil act of March 3, 1899, the commission has allotted the sum of $25,000 for the care of and repairs to plant in the First and Second districts.

Accompanying this report and forming part of it are the following papers and drawings:

Report of Assistant Engineer Nolty on operations in First district.
Report of Assistant Engineer Rees on operations in Second district.
Report of Assistant Engineer LeVasseur on operations at Nonconnah Rock.
Report of Assistant Engineer Nolty on repairs to plant.
Map of New Madrid front.
Map of river near Point Pleasant, Mo.
Drawing of Abattis dikes.
Map of Caruthersville, Mo.
Map of Plum Point Reach.
Map of Memphis and vicinity.
Map of Nonconnah Rock.
Map of Helena front.
Map of levees, First and Second districts.
Map of First and Second districts, showing overflow of 1899.
Profile Lower St. Francis Levee district.
Profile Upper Yazoo Levee district.
Profile White River Levee district.
Abstracts of proposals.
List of civilian engineers employed from May 1, 1898, to April 30, 1899.

Respectfully submitted.

E. EVELETH WINSLOW,
Captain of Engineers.

Col. G. L. GILLESPIE,
Corps of Engineers, President Mississippi River Commission,
Army Building, New York City.

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Financial statement.

IMPROVING MISSISSIPPI RIVER, FIRST AND SECOND DISTRICTS.

July 1, 1898, balance unexpended	$128,989.89	
June 30, 1899, amount appropriated and allotted since last statement	921,750.00	
February 17, 1899, amount received from B. F. Dame, for rent of island in Mississippi River, near Australia, Miss., for year 1899	1.00	
		$1,050,740.89
June 30, 1899, amount expended from July 1, 1898, to date	382,483.73	
October 11, 1897, amount of Treasury settlement No. 2488 (not taken credit for in my last financial statement)	.20	
August 13, 1898, amount of Treasury settlement No. 5260	8.77	
August 29, 1898, amount of Treasury settlement No. 5201	9.90	
February 17, 1899, amount deposited to credit of Treasurer United States on account of rent of island in Mississippi River, near Australia, Miss., for year 1899	1.00	
April 5, 1899, amount transferred to Capt. Mason M. Patrick, Corps of Engineers	16,071.02	
		398,574.62
June 30, 1899, balance unexpended		652,166.27
Outstanding liabilities	10,600.00	
Amount covered by uncompleted contracts	6,867.73	
		17,467.73
Balance available		634,698.54
Amount that can be profitably expended during the fiscal year ending June 30, 1901		1,000,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

REPORT OF MR. AUG. J. NOLTY, ASSISTANT ENGINEER, UPON WORK DONE IN FIRST DISTRICT, IMPROVING MISSISSIPPI RIVER, DURING SEASON OF 1898–99.

MEMPHIS, TENN., *April 30, 1899.*

SIR: I have the honor to submit herewith my annual report of operations of construction parties in First district, improving Mississippi River, during the season of 1898–99.

NEW MADRID, MO.

The season's project for work at this place called for an extension downstream of 1,600 feet of the existing revetment of the town front. An examination made by me shortly after the beginning of the season's work prompted me to recommend to the district officer a change in the project, namely, that the downstream extension should be carried to a distance of 1,200 feet only and that about 400 feet be added at the head of the existing work, where there were unmistakable signs that erosion would soon attack the then head of the work. This recommendation was, after a personal examination of the locality, approved by the district officer, and the project thus modified was carried out.

The work done here, as well as all other revetment work at the places mentioned hereafter, is of the standard fascine-mat type. The river mattresses are 265 feet wide, with shore edge lying, wherever practicable, a little above the wet contour, the bank above being graded to a slope of 1 on 3 and then paved with riprap lying on a 4-inch foundation of quarry spalls, the riprap being 8 inches thick at the water's edge and tapering off to 6 inches at the upper limit of the paving, this limit corresponding to about the 33-foot stage. Where, owing to deep indentation of the shore line, it was impossible to lay the shore edge of the river mats upon the dry bank, connecting mats were used to make the proper connection between the former and the shore. Where the edge of the mat joined the paving an extra ridge of riprap was laid. Should a slight separation between the mat and paving take place, the extra stone piled along the junction would drop down and close the ruptures. As a matter of fact, only one small connecting mat was required for the purpose of making the proper connection, the extreme pliability of the mat permitting of its

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closely following all but the very deep indentations of the shore line. A second connecting mat was required, because the river had submerged the shore edge of the river mat before the paving could be laid.

The following is a brief chronological history of the various allotments and of the work done here, viz: 1893, allotment $25,000, revetment constructed, 900 feet, from Dry Slough down; 1894, allotment $20,000, revetment constructed 725 feet, extension downstream of the former work; 1896, allotment $16,000, revetment constructed 525 feet, downstream extension; 1898, allotment $50,000, revetment constructed 1,218 feet, from lower end of 1896 work down, and 355 feet above the head of the 1893 work; total for 1898, 1,573 feet; total allotment, $111,000; total revetment, 3,723 feet; total length of bank covered, 3,643 feet, about 80 feet of mat being expended in laps.

The river front of the town is now amply protected against caving, and no further work is required for that purpose. The bend below the revetment, however, is caving actively, while the bar opposite is advancing at a rate equal to the recession of the bank.

The so-called Dry Slough is a wide slough bed which begins to fill up when the river attains a 30-foot stage. When the river begins to recede from a flood stage, the flow through this slough is very rapid, and extensive caving of the west bank of it, which is the eastern boundary of the town, takes place. Something to check this caving will soon have to be done, but whether this work should be done by the local authorities or by the United States is not my province to say.

The season's work was prosecuted under very adverse conditions as to stage of river and conditions of weather. Much rain fell, and while most of it fell at night and consequently did not interfere directly with the working force, it caused a brush famine by reason of the boggy condition of the brush bars. Scarcity of brush of course meant delay to the work. Labor, too, was quite scarce, and of very indifferent character. The stage of river remained so high throughout the season that practically there was no low-water season. The lowest reading at New Madrid was 7.25, and that only for a few days.

Work was begun September 18 and completed December 2.

The following is a detailed statement of work done and the cost thereof:

Labor and subsistence	$15,991.96
Brush, 5,962.4 cords	6,191.9[illegible]
Poles, 171.5 cords	257.25
Wire strands, 38,314 pounds	961.[illegible]3
Wire, annealed, 8,202 pounds	147.64
Wire, silicon bronze, 950 pounds	128.24
Clips, 4,975	230.6[illegible]
Staples, spikes, and nails	23.21
Stone, 5,574.8 cubic yards	6,550.0[illegible]
Lumber	201.40
Fuel and engineer's supplies	1,143.04
Miscellaneous materials	302.63
Manila rope	1,486.40
Towing	6,012.09
Total	39,627.77
River mattress:	
No. 1	$20,094.67
No. 2	7,703.60
Connecting mattress:	
No. 1	775.04
No. 2	643.09
Paving	10,304.30
Crib dike	107.07
Total	39,627.77

Total length of revetment for 1898, 1,533 linear feet; cost per linear foot, $25.85; cost of mattress per square, $6.77; cost of paving, $6.72 per linear foot.

CARUTHERSVILLE, MO.

The project for the protection of the river front of this town contemplated the construction of four brush and stone spurs founded upon fascine mats. These latter were to be 200 feet wide, from the low-water contour out, and 120 feet long. The spurs to consist of two cribs each, the bottom one being 150 feet long, 20 feet wide, and 8 feet high; the upper one to be 10 feet base, 8 feet high, and to run from the

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top of the graded bank to near the outer end of the sill mat. The bank in front of each sill mat to be graded to a slope of 1 on 3 for a distance of 80 feet from the head of the mat downstream; this slope, where not covered by the crib, to be paved in the usual manner. As the river was considerably above the zero stage, and in order to comply with the specifications in the project, which called for the mats to extend 200 feet outstream from the zero contour, these mats were made 220 feet wide. It was also intended to give the top cribs 12 feet base instead of 10 feet, in order to insure greater stability. The distance between centers of spurs is 470 feet. and the total distance covered by the work is 1,530 feet, counting from the head of the upstream sill mat to the foot of the downstream one.

On October 31 construction plant arrived here from New Madrid. While awaiting definite instructions for the beginning of work, the first of the sill mats was started on the ways; none of the work, however, being launched off. On the evening of November 1, telegraphic orders not to do any work here, as the project had not yet been approved, were received. As approval of the project was not expected for at least ten days, all plant was moved down to Plum Point Reach, where considerable repair work was to be done. The section of mat already constructed and still on the ways was utilized on the Plum Point work. The actual beginning of the work here was therefore delayed until November 28, by which time the mat outfit could be spared from Plum Point without seriously interfering with the progress of that work. This delay of nearly one month was, as it afterwards turned out, very unfortunate, as it prevented the completion of the project. Sill mats Nos. 4, 3, 2, and 1 were rapidly completed in the order named. As soon as the lower mat, No. 4, was sunk, the grader was put to work grading the bank in front of the mat, and continued this work as fast as the successive mats were sunk. While the last of the mats was under construction ice began running in the river, and this compelled a stoppage of the work, and the placing of the outfit into places protected from the ice. Eighty-five feet of mat was lying afloat. This was also moved out of reach of the ice, and subsequently moved back into position, and extended to its full length. Four days were lost on account of running ice. By the time the last mat was sunk, ice was reported again running heavily at Cairo, and two days additional were lost while awaiting further information regarding the situation, it not being deemed advisable to begin construction of the heavy cribs until there was a certainty of no interruption from ice. As the reports were favorable, the construction of Crib No. 1, Dike No. 4, was begun, although the river was high and rising, it being deemed very essential that the project should be completed by the end of the working season, if possible.

The river continued rising, bringing down much heavy drift, a large part of which lodged against the mooring barges. The current was very strong, and in attempting to lower the finished crib to bottom, the pressure of the drift and current against the 8-foot wall of crib was too strong for the mooring cables to successfully resist. Three of these, two 1-inch steel and one 2¼-inch manila, parted, while a fourth one pulled out its anchorage. This set the whole plant of seven pieces adrift. The crib was promptly let go upon the first sign of disaster and sank to the bottom, but not in its proper position, the outstream end being forced a considerable distance downstream. The location of this crib on the map is approximate only, it being impossible at the time to make any soundings, or other examination, to determine its precise location.

The plant floated down the river, there being no steamer near by at the time, and was finally tied up 6 miles below.

The indications being for a continued rise, and it being now the middle of January, all work was abandoned for the season. The condition of the work was then as follows: All the sill mats, four in number, were in place; grading of bank in front of each mat completed, each graded slope being 80 feet wide and running from top of bank to water surface on a grade of 1 on 3; slopes in front of mats Nos. 4, 3, and 2 paved, and Crib No. 1 of Dike No. 4 sunk.

Had it been possible to begin work when the plant first arrived here, or had we had a duplicate mat plant, the project would have been completed before the advent of very high water. It is, however, believed that, incomplete as the work is, it will exercise some protective influence, for one season at least, upon that part of the town front for the protection of which it was designed.

From a study of the conditions prevailing here I am led to the conclusion that the protective works as designed are too slight and cover too small an extent of bank to permanently resist the encroachment of the river. The depth of water along the outer ends of the spurs is about 43 feet below mean low water, New Madrid gauge, the current is very strong, and the caving extensive. Caving would continue above and below the work, so that in a comparatively short time the work itself would form a salient or false point. As the bank above and below receded, the caving would work behind the spurs and eventually destroy them by isolation. I would respectfully suggest that in lieu of the spur-dike revetment a continuous revetment

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of standard type 3,000 feet long be placed here. The sill mats now in place, aggregating 480 linear feet, could be incorporated as part of the 3,000 feet. Such revetment, wherever placed, has up to date held intact. The 3,000 feet recommended would afford ample protection to the town. About 1,500 feet below where this proposed work would terminate, the United States levee approaches very close to the caving bank. As the present levee location can not be abandoned except at great cost, it may be desirable to carry the revetment down that far.

The following is a statement of the work done and its cost:

Labor and subsistence	$7,904.6
Brush, 1,808.8 cords	1,881.5
Poles, 130.4 cords	195.6
Wire strand, 11,530 pounds	333.9
Wire, annealed, 5,621 pounds	168.6
Wire, silicon bronze, 213 pounds	27.7
Clips, 722	206.8
Staples, spikes, and nails	26.0
Stone, 1,820 cubic yards	2,083.8
Fuel and engineer's supplies	351.9
Miscellaneous materials	165.5
Towing	2,376.2
Total	15,661.1
Sill Mat No. 1	2,586.3
Sill Mat No. 2	2,804.5
Sill Mat No. 3	3,181.9
Sill Mat No. 4	3,664.2
Crib No. 1, Spur No. 4	3,423.2
Total	15,661.1

Cost of sill mats includes 800 square yards of paving for each mat.

PLUM POINT REACH.

Ashport Bend, Tennessee.—The initial work of revetting this bend was done in 1882, when about 1,800 feet of old-style river mat, 125 feet wide, was placed in front of the town of Ashport. Nothing else was done here until 1891, when the complete revetment of the bend was begun at a point about 3,000 feet below the town. Work was continued in 1892, 1893, and 1894, being completed in the latter year down to the head of the Gold Dust dikes. The total length of the work, exclusive of the 1882 piece, is 16,600 feet, of which all but 1,800 feet is of the old type of river mats from 200 to 300 feet wide. A considerable amount of repairs was found necessary after the flood of 1893, all at the lower or Gold Dust end. No further damage was noticed until after the subsidence of the flood of last year, when five faults, located between ranges 24 to 26, were visible. Two of these faults were simply enlargements of old "pockets," left without any high-water bank protection when the revetment was repaired in 1893. These had suffered no damage until the high water of 1897. The growth of the bar opposite and the consequent reduction in area of waterway was undoubtedly the main factor in causing the sudden enlargement of these "pockets" and in the development of the other three faults by largely increasing the strains against this section of the work. The river mats are believed to be intact, they having simply followed the scour along their outer edge. This settlement caused a rupture between the river mats and the shore work.

Work was begun here on January 10, with a high and rising river. A pocket mat 210 feet long was started in the largest fault, and continued until the 14th under difficulties caused by high river and heavy drift running continuously. As the river was too high and too full of drift to do the work properly, and as it was apparent that no improvement of these conditions need be looked for for some time, work was discontinued for the season. The piece of mat constructed was sunk in place and 260 cubic yards of spalls still remaining on contractor's barge were unloaded to the bank, after which all plant was removed and the working force disbanded. With this the season's construction work closed. Failure to complete this and the Caruthersville work is as much due to the lack of a duplicate mat plant as it is to the continued high stage of river during the working season. The lack of plant prevented us from carrying on work at more than one place at any time, besides entailing expense in moving plant back and forth. In speaking of the lack of a duplicate mat plant no account is taken of the old unserviceable plant used at Point Pleasant, for this was entirely unfit to withstand the strains it would be subjected to in mat construction. Besides, this plant was in use on the abatis work

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whenever the stage of river permitted this work to be prosecuted. Even with the plant then available much more work could have been accomplished had we had anything like our usual working season. But instead of the usual long periods of low water the river during the past season was continually oscillating, the extremes being from 7.25 feet, the lowest, to 28.60 feet, New Madrid gauge.

All brush and poles were furnished by Messrs. Hunter and Frey, of Memphis, Tenn., at $1.04 and $1.50 per cord, respectively, delivered on United States barges at contractor's camp. Riprap and spalls were furnished by Fred. Hartweg, Cincinnati, Ohio, at $1.185 per cubic yard for riprap and $1.095 for spalls, delivered at New Madrid. Both contractors have given entire satisfaction in every respect. While it is true that the brush supply was sometimes short, this was not due to any fault of the contractor, but was altogether due to the impossibility of hauling over the boggy roads on the brush bars.

The cost of these repairs at Ashport Bend was $908.41.

Fletchers Bend, Arkansas.—This has for the past decade been one of the worst caving bends on the river. In 1884 revetment work was begun about 2,500 feet below the mouth of Mill Bayou, and 3,100 feet of it completed that year. This revetment consisted of the old-style subaqueous mat with brush upper bank revetment ballasted with riprap. In the summer of 1885, or about eight months after completion of the work, 2,875 feet of the work was in position, the balance having been destroyed by caving. Lower down in the bend a second piece of revetment, about 1,400 feet long, had been placed in 1884; this was completely destroyed after the flood of 1886. In 1888 work was resumed in this bend and continued at intervals until 1896, by which time the revetment extended to within a few hundred feet of New Haven Landing. Caving, at all times active, became particularly so after the closure of Elmot and Island 30 chutes. This caving attacked the unprotected bank above the 1884 work, and, working down, began the destruction of that revetment, continuing to do so until now there remain but about 900 feet of the old work. Late surveys show that the low-water width of the river opposite Mill Bayou and for some distance down is but 1,500 feet, while immediately above and below this width is 4,500 and 4,200 feet, respectively.

In 1898–99 project for work at Plum Point was included the protection of this work by the construction at its head of a brush and stone spur, founded on a fascine sill mat of proper dimensions, the paucity of funds available preventing any work in the caving bend itself, the object of the spur being simply to prevent any further disintegration of the work until such time as the bank above could be properly revetted.

While spurs are admirably adapted to check the encroachment of the river for a time, such works are, at best, but temporary expedients, as the caving from above will eventually attack the shore end of the spur, isolating it from the bank, and thus rendering it practically useless.

Operations were begun here November 5 with the construction of a sill mat, the section of mat on the ways, which had been designed for use at Caruthersville, being widened out to 255 feet and finished to a length of 207 feet. After the mat was sunk the grader was put to work grading a section of bank, 150 feet long, in front of the mat. This slope was paved in the usual manner. That part of the slope which would be covered by the crib to be built was left unpaved. The upper end of the paving coincided with the upper edge of the sill mat.

Crib No. 1, whose dimensions were to be 204 feet long, 24 feet wide, and 8 feet high, was started as soon as the ways were clear. The river being quite high and rising, and there being no prospect of it soon declining, it was, in view of the strong current running here and the large quantities of drift coming down, deemed unsafe to attempt the sinking of the crib under prevailing conditions. Hence, after the substructure of the crib had been built to a thickness of 2.5 feet, it was launched and tied up alongside the bank. The plant was on November 22 moved to Osceola Bar to work there in the interim, returning to this place on December 20, upon which day the completion of Crib No. 1 was begun. This crib was successfully placed in position despite the very strong current, and the construction of No. 2 was at once begun. Crib No. 2, which is 208 feet long, 12 feet wide, and 8 feet high, was sunk on January 9. This completed the work here. Most of the stone used here was taken from the storage piles lower down in the bend, it being loaded on barges and towed up to the work.

Statement of cost.

Labor and subsistence	$4,221.18
Brush, 1,232 cords	1,281.28
Poles, 157 cords	235.50
Wire strand, 10,434 pounds	256.16
Wire, annealed, 5,166 pounds	95.80
Wire, silicon bronze, 96 pounds	12.96

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Staples, spikes, and nails	$5.27
Clips, 628	27.37
Stone, 779.7 cubic yards	914.15
Fuel and engineers' supplies	223.60
Miscellaneous materials	52.80
Towing	1,132.72
Total	8,458.82

Sill mat	3,899.67
Crib No. 1	3,057.44
Crib No. 2	1,318.06
Paving	183.75
Total	8,458.82

Osceola Bar, Arkansas.—Upon recession of the flood of 1898 some damage to the revetment of this island became visible, the most extensive being between ranges 48–50, where, for a continuous distance of 770 feet, the upper bank protection was completely destroyed. In addition, there were also two detached faults of a similar nature, but of small magnitude, in the vicinity of the larger one. At the head of the bar there was one small fault in the revetment itself, and a deeper washout just above the upper edge of the work. All the faults, except the last-mentioned one, were repaired by constructing connecting mats of such width as to restore connection between the river mats, which were found to be in good condition, and the shore, and then grading and paving the above-water part of the bank. The washout was repaired, or rather its enlargement prevented, by placing a brush and stone sill, founded upon a fascine-sill mat, across it. The repairs at the lower end of the bar involved the construction of 605.45 squares of connecting mat, the removal of 46,837 cubic yards of earth, and the laying of 4,656 square yards of paving. Those at the head required 33.8 squares of connecting mat, 48.4 squares of sill mat, 4,050 cubic feet of crib, and 1,206 square yards of paving. All work was completed here by December 20, on which day the plant was returned to Fletchers Bend.

Nearly all the revetment of this bar is of the old type; that is, of woven river mats with brush shore work lightly ballasted. Damage to the shore work, amounting to a complete renewal, may be expected in the near future, as the brush composing the shore work is now entirely decayed. All mat work used in the repairs is of the modern fascine type.

Statement of cost.

Labor and subsistence	$3,144.94
Brush, 1,052 cords	1,094.08
Poles, 10 cords	15.00
Wire strand, 6,318 pounds	160.39
Wire, annealed, 1,962 pounds	37.10
Wire, silicon bronze, 52 pounds	7.02
Clips, 675	27.30
Stone, 1,902 cubic yards	2,476.14
Miscellaneous materials	39.10
Fuel and engineers' supplies	224.10
Towing	1,291.01
Total	8,516.18

Mat No. 1, foot of Osceola Bar	1,450.91
Mat No. 2, foot of Osceola Bar	1,423.90
Mat No. 3, foot of Osceola Bar	687.46
Mat No. 4, foot of Osceola Bar	755.15
Mat No. 5, foot of Osceola Bar	818.93
Mat No. 6, foot of Osceola Bar	345.61
Paving, foot of Osceola Bar	1,961.26
Head of Osceola Bar	1,068.96
Total	8,516.18

Point Pleasant, Mo.—Twenty-five thousand dollars having been allotted by the commission for a practical application in the Mississippi River of the reversed abatis deflecting dikes, designed by Lieut. Col. Amos Stickney, Corps of Engineers, the bar opposite Point Pleasant, Mo., was designated as the site of the first work of this character. Along this stretch of river the low-water navigation has been very bad owing to the existence of secondary channels. In order to concentrate the flow

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into one channel, a system of three dikes, each about 1,000 feet out from the shore of the bar, was projected, located as shown on the accompanying map. The sketch submitted herewith shows a section of abatis in elevation and in detail. When the last section was ready for launching, it was intended to obtain photographic views of the structure on the ways and in the act of sliding off, but after one view had been obtained a heavy rain storm set in and no other view could be obtained.

Proposals for furnishing the lumber, bolts, spikes, wire strand, and other material required were invited from dealers. D. Mathews, of Luxora, Ark., being the lowest bidder for the lumber, namely, $8.50 per 1,000 feet B. M., the contract was awarded to him September 19, under an agreement that deliveries should begin within twenty days after receipt of order. On October 3 this man informed me that he would be unable to deliver in less than thirty days after that date. As this would have caused considerable delay, I was authorized by the district officer to cancel the contract with Mathews and make arrangements with other parties, bearing in mind that time was the most essential consideration. The contract was therefore given to F. L. Peck, Hathaway, Tenn., at $9.50 per 1,000 feet B. M., delivered on United States barges, and promptly filled by him. One hundred and twenty-two sticks of piling were purchased from Fred. Hartweg, of Cincinnati, Ohio, at 3¼ cents per foot on the ground. These piles were then lying along St. Johns Bayou, just above New Madrid. They were hauled out to the river bank and loaded upon a barge by hired labor. Subsequently 120 additional piles were purchased from Laswell & Hopper, of Carnthersville, Mo., at 8 cents per linear foot, those previously purchased at New Madrid having been found rather weakened by reason of having been cut a year or more prior to their purchase. Most of the first purchase were, however, used as at first intended.

Work on Dike No. 1 was begun October 20 by driving the anchor and mooring piles for the first section of abattis. The anchor piles were driven 20 feet apart and on a line 50 feet above the toe of the dike. The instructions called for the driving down of the anchor piles so that they would not project more than 2 feet above the bottom. To accomplish this a follower was at first used, and while this worked satisfactorily in water whose depth did not exceed 12 feet, this method was not satisfactory in greater depths. Hence, thereafter all piles were cut long enough to project a few feet above the water surface after the proper penetration (15 feet) had been attained. At a distance from the foot of the pile equal to the penetration plus 2 feet, two saw cuts were made from opposite sides, in such a manner that the section was reduced about one-half. After the abattis was launched into place and the piles were of no further use they could then be easily broken off, thus leaving no obstruction standing liable to injure vessels. Each anchor pile carried three-eighths-inch wire-strand cables fastened securely to the head of the pile, each cable being long enough to reach the section of the abattis 50 feet below, to each frame of which one cable was securely fastened. The mooring piles were driven about 250 feet above the line of dike and were simply used to hold and maneuver the pile driver and launching barge. They were broken off after use. The outside mooring pile of one section became the inshore one of the next section.

Each section of abattis was made 245 feet long, 20 feet wide across the ground poles, and from 9.5 to 15 feet high, the height being measured from the ground poles to top of screen poles. The least height was for comparatively shoal and the other for deeper water, the object being to have the tops of the screen poles at or near low water. Each section consists of 38 triangular frames of sawn timber, well bolted and spiked together, and connected together with waling pieces and stringers, the frames being spaced 6.5 feet centers. Upon the skeleton structure thus formed are placed the ground and screen poles, spiked and wired down, the brush foundation for the stone ballast, and, finally, the wattling to form an apron for the overfall. Three poles, graduated into feet and tenths and long enough to project well above the water surface, were spiked to the section, one at each end and one in the middle. These poles were perpendicular to the base, and from them could be noted the amount and direction of settlement of the sections.

The sections were built upon two ordinary mat barges, coupled together and lying alongside the bank. The barges containing the finished frames, the poles, brush, and stone lay on the outside of the mat barges. To prevent premature sliding off, the section was fastened to the launching ways with wire ties. These were cut just prior to launching off.

As soon as a section was completed it was towed out to a little above its proper position, lines run from the mooring piles to each end of the mat barge, which latter was then slacked off until the toe of the section was on the proper line, care being taken to have each section just in rear and clear of the one launched off previously, and to have the latter overlap the one about to be launched off by 5 feet. The three-eighths-inch cables were then passed from the anchor piles to the barge and each cable well fastened to its proper frame, care being taken to equalize the strains on all the cables. The wire ties were then cut, and at the word of command the

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mooring lines were thrown off, when the section slid into the water. In launching off the first section it was attempted to slide the structure off gradually by means of slip lines carefully slacked off, but this method did not work well, as nothing could hold the heavy structure when once it started to move. Hence the slip lines were abandoned and the section allowed to go by the run. This has always proven successful, no damage whatever to the abattis having resulted therefrom. In launching the sections invariably plunge downward, so that the base assumes the perpendicular and maintains this position until a strain is thrown on the anchor cables, when the current throws it into its proper position on the bottom. After the first launch it was found that many of the outboard extensions of the launching ways were broken off, they not having sufficient strength to bear the heavy weight. This was remedied by substituting for every alternate extension full-size piles, which were securely lashed to the fixed ways and allowed to extend outboard the same distance as the extended ways.

After section 1, Dike No. 1, was placed it was decided, in view of the high stage of the river and consequent deep water where the anchor piles for section 2 were to be driven, to temporarily suspend work on Dike No. 1 and to move down to Dike No. 3, where shoaler water would be found. The river, however, continued to rise, and after the first section of Dike No. 3 was launched there was little difference in the depth at either place. Dike No. 3 was completed to a distance of 982 feet from the shore line of the bar out. The depths ranged from 8 to 38 feet. To prevent cutting around the shore ends a small brush and stone crib was placed between the shore end of the dike and the dry shore.

In compliance with orders received further work was suspended upon completion of Dike No. 3, to be resumed upon the existence of more favorable conditions. All plant was therefore removed to Caruthersville. This step was rendered necessary by the continued high stage of the river, which made operations both difficult and expensive. On January 6 prospects for a more favorable stage were promising; hence work on Dike No. 1 was resumed. Hardly, however, had the work fairly begun when another rise set in. The river was already very high, and by the time section 2 of Dike No. 1 was ready for launching the bar was almost completely submerged. The river was full of heavy drift, and this broke off 4 of the anchor and 1 mooring pile, besides so badly fouling some of the cables that only 9 out of the 36 could be secured to the section. The section was, however, launched and placed without any mishap, except that it has more lap than necessary.

With the placing of this section work was finally abandoned for the season. Soundings above and below the sections were periodically taken to determine the action of the abattis. These, while continued only for a short time, show that a fill takes place in front and rear of the sections, the fill being greatest in the rear; that the height of the fill ranges from 2 to 8 feet, and that scour takes place at the free end of the last section, this scour increasing in depth as the structure is pushed out into the river.

From the readings of the gauge poles, and from the change in perpendicularity of these, it appears that the sections settle only at the toe, they usually lying flat on the bottom after launching, with the poles perpendicular, or nearly so, to the water surface, and then tilting forward or upstream, thus showing plainly that the section was settling along the upstream edge. This settlement, however, soon ceased, and never amounted to more than 3 feet, after which no further movement was observed.

This type of closure work recommends itself for its cheapness and for the rapidity of construction. That it will prove itself well adapted for the purpose of closing chutes, or secondary channels, I have no doubt. It is to be regretted that the very unfavorable season prevented the completion of the three dikes designed for Point Pleasant, but it is believed that, incomplete as the work now is, favorable results will be shown therefrom at the next low-water period.

Despite the most adverse conditions of weather and stage of river, and laboring under the additional disadvantage of shortage in the required plant, Dike No. 3 was completed at a total field cost of $2.91 per linear foot. With more favorable conditions prevailing, the work can be done for not more than $2 per foot and at a rate of 100 feet of completed dike per working day. The principal delay has been in the pile driving. When working in shoal water, or with an additional driver in deep water, this delay would be avoided. The maximum force of laborers employed was 40 for a single plant. One carpenter, one steam engineer for the pile driver, one overseer, and two master laborers completed the force. A steam tender, of sufficient power to handle the mat barges against a strong current, should be with the party. During the past season we had only the steamer *Chisca* available, and as this boat had to serve four construction parties, working over a distance of 90 miles, the failure of the boat to arrive in time to place the mat barges, when a section was ready for launching, caused delays. Of course the force would then be idle until the barges were cleared for the construction of another section.

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Statement of cost.

Labor and subsistence		$2,995.17
Lumber, 27,120 feet		257.69
Brush, 93 cords		96.72
Poles, 205 cords		307.50
Piling, 4,177 feet		208.55
Wire, spikes, and nails, 10,660 pounds		225.00
Bolts, 672		17.04
Clips, 211		21.10
Stone, 3,206 cubic yards		379.70
Fuel and engineer's supplies		116.85
Miscellaneous materials		31.07
Total		4,656.29

Work done, 1,472 feet. Cost per linear foot, $3.16.

Dike No. 1:		
Abattis	$1,642.73	
Mat	67.25	
		$1,709.98
Dike No. 3:		
Abattis	2,919.91	
Mat	26.40	
		2,946.31
Total		4,656.29

Before closing, I would like to call attention to the gratifying fact that no damage whatever has been sustained by the modern type of revetment works, although some of it has been down since 1893. This class of work is to-day practically as good as when placed.

Respectfully submitted.

AUG. J. NOLTY, *Assistant Engineer.*

Capt. E. EVELETH WINSLOW,
Corps of Engineers, U. S. A.

REPORT OF MR. W. M. REES, ASSISTANT ENGINEER, ON WORK IN SECOND DISTRICT, DURING SEASON OF 1898–99.

MEMPHIS, TENN., *April 30, 1899.*

CAPTAIN: I have the honor to submit my report upon work done in Second district, improving Mississippi River, during the season of 1898–99.

1. Hopefield Bend, Arkansas.
2. Memphis Harbor.
3. Dredging operations in Wolf River.
4. Helena, Ark.

HOPEFIELD BEND, ARKANSAS.

The high water of the spring of 1898 ruptured the revetment work at several places along the downstream half, the principal break being at the junction of the 1891 and 1892 work, or about 300 feet below range No. 11. Here, for a length of 300 feet, the revetment was badly broken, all the shore work having disappeared, and the shore edge of the river mattress, formerly at the zero contour line, had settled to a depth of 30 feet below it. Probings disclosed the presence of the river mattress all around the river rim of the pocket, but no doubt the part in the pocket was badly broken.

Repairs were made by sinking a fascine mattress in this pocket 300 feet long, 100 feet maximum width, and containing 235 squares. This mattress was cribbed up along the shore edge to restore the slope to the normal and the bank then graded by the hydraulic method and paved with stone up to the 23-foot stage.

There was a second break, 100 feet long, about 700 feet below the first mentioned, affecting the river mattress only slightly and extending about halfway up the paved slope. Repairs were made to this by placing a fascine connecting mattress 120 feet long and 50 feet wide, and containing 60 squares; grading the bank along this by hand labor, and paving the same with stone.

Slight ruptures in the revetment had also occurred at two localities near the downstream end of the work, the paved bank exhibiting longitudinal cracks and a set-

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tling of the lower portion 2 or more feet. One of these places was opposite the head of the railroad incline, was about 100 feet long, and extended to the low-water stage.

This was repaired with a mattress 100 feet long and 21 feet wide, containing 21 squares, then tearing up the old paving, regrading the bank, and replacing the paving with some additional stone. A similar rupture, about 100 yards long, was about 300 yards below this. It was repaired in the same manner, but without mattress work.

The work at Hopefield Bend was begun October 31 and completed November 19. Three hundred and sixteen squares of mattress work was built and sunk; 360 linear feet of bank was graded by the hydraulic process, removing 8,700 cubic yards of earth, and 3,388 square yards of bank was paved. The total field cost of the work was $4,695.36.

The following is a statement of the work done in detail and the cost thereof:

Pocket mattresses.

Labor and subsistence	$530.75	
Brush, 578.7 cords	601.85	
Poles, 58.8 cords	88.20	
Wire strand, 10,030 pounds	252.51	
Wire, galvanized, No. 12, 11,000 pounds	205.50	
Stone, 400 long tons	544.00	
Miscellaneous materials	1.71	
		$2,224.52

Work done: 316 squares, $7.039.

Paving bank.

Labor and subsistence	572.05	
Stone, 1,198.25 long tons	1,629.62	
Grading bank (8,700 cubic yards, at $0.0309)	269.17	
		2,470.84
Total cost		4,695.36

Subsistence: Rations issued, 289.

Cost of subsistence stores	$90.22
Cost of subsistence services	51.67
Total cost	141.89

Cost per ration, raw, $0.3122; cost per ration, served, $0.4910.

All repair work done was along bank having river mattresses of the old style, which are so open that in strong currents the earth beneath is scoured out, permitting the mattress to settle. This fact has been proven by a comparison of depths obtained at different times at the same localities.

When fascine mattresses were placed no such settling was observed.

It would probably be wise, as a preventive of future caving, to place over these old style woven mattresses those of the fascine type, especially along the downstream half of the revetment, where high-water velocities are great and where any serious caving would destroy the present trend of the current, making whirls and eddies and rendering still further caving probable. The importance of holding this bank line is great, for further recession will cause the current to impinge lower against the paved landing of Memphis Harbor and permit the bar above it, which now covers one-half of the landing, to extend downstream, and probably ere long cover the entire landing. To carry out the plan of a more effective protection of Hopefield Bend will require the placing of about 3,300 linear feet of fascine mattresses, about 250 feet wide. Of these, 1,400 linear feet will be required near the railroad incline, covering work of 1892, and 1,900 linear feet covering the work of 1890 and just above it.

As no bank paving work is required, this being in good condition, the cost of the proposed work per linear foot should not exceed $17, or a total of $56,000 will put this part of the revetment in first-class condition.

MEMPHIS HARBOR.

By act of Congress July 1, 1898, the sum of $35,000 was appropriated for work at this harbor. The project submitted for the expenditure of the funds was to extend the revetment of 1896 downstream to connect with the revetment of the Kansas City and Memphis Bridge Company. The unprotected portion of the bank was about 1,200 feet long, situated along a high bluff bank in the southern portion of

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the city, and which had been caving, though slowly, for many years past. Its revetment completes the bank protection work along the entire river front of the city.

The work done was placing a continuous mattress of brush work along the exposed bank, well lapping the 1896 revetment above and the bridge revetment below, having a width of 300 feet and reaching from about the low-water contour to the line of greatest channel depth. The bank above the mattress was graded to a slope of 1 on 3, and paved with stone up to the 20-foot stage of the Memphis gauge.

Preparations for the work were begun in August, 1898, by repairing and equipping plant and by the purchase of materials and supplies. Brush and poles were furnished by contractors at $1.04 per cord for the former and $1.50 per cord for the latter, all loaded on Government barges at contractors' camp, which was a few miles upstream from Memphis. Stone was obtained by contract from railroad quarries in Arkansas and loaded on Government barges at West Memphis, the price paid being $1.36 per cubic yard, or ton of 2,240 pounds, f. o. b. barges.

On September 14 the plant was placed at the site of the work and operations begun by grading the bank and placing anchorages for the river mattress. It was not, however, until October 3 that mattress work was started, the delay being caused principally by the quarantine established here to prevent the appearance of yellow fever then prevalent in the South. This restricted the labor supply, both for the construction work and the work of the brush and stone contractors.

The river mattress, which was 1,220 feet long and 300 feet wide, was successfully sunk on October 28. It extended from Station 24–97 to Station 37–17, lapping the 1896 work 50 feet and the bridge work about 5 feet.

It was of the usual fascine construction, sewed together with wire strand on lines 8 feet apart, cabled on top with heavier strands, and with all wire connections secured with clips at every 8 feet. The whole was a carpet of brush work 1 foot thick, securely tied together, and so compact as to make scouring through it impossible even when exposed to the strongest river currents.

To join the river mattress with the shore there was required at one place a connecting mattress 208 feet long and 25 feet wide.

While the mattress work was in progress the bank above was being graded, and was subsequently paved with small rip-rap stone, closely laid together on a bed of spalls about 3 inches thick, the thickness of the completed paving being about 11 inches.

This paving and with it the entire work was finished on November 14, the amount of bank paved being 7,760 square yards.

The work was done by hired labor; common laborers were paid $1.20 per day of eight hours, without subsistence. The Government, however, subsisted the monthly employees, such as foremen, clerks, watchmen, boatmen, etc. Fairly favorable conditions of the river and weather prevailed while the work was in progress, the stage of the river varying between 4.6 and 7.9 feet during the time of mattress building, and reaching a maximum of 11.7 feet while paving was in progress. The time lost by rain was five and one half days.

The details of work done, cost, etc., are as follows:

River mattress.

Labor and subsistence	$5,457.73
Brush, 5,550.9 cords	5,772.93
Poles, 213.2 cords	319.20
Stone, 2,938.1 tons	3,995.68
Wire strand, 40,037 pounds	1,009.81
Wire, galvanized, No. 12, 15,070 pounds	252.66
Wire, silicon bronze, No. 9, 1,268 pounds	171.18
Clips, 5,052	224.94
Rope, manila, 4,098 pounds	392.18
Oils and engineer's supplies	31.00
Miscellaneous materials	179.62
Superintendence	693.05
Care of plant	481.78
Repairs to plant	838.61
Towing	859.02
Miscellaneous expense	168.00
Total	20,847.39

Work done: 3,660 squares; cost per square, $5.70.

Material used per square: Brush, 1.51 cords; poles, 0.058 cord; stone, 0.803 long ton; ½-inch wire strand, 5.88 pounds; ⅜-inch wire strand, 4.59 pounds; ¼-inch wire strand, 0.46 pound; No. 12 galvanized wire, 4.11 pounds; silicon bronze wire No. 9, 0.34 pound; clips, 1.38.

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Connecting mats.

Labor and subsistence	$77.00
Brush, 74 cords	76.96
Stone, 100 long tons	136.00
Wire strand, 500 pounds	13.17
Superintendence	11.56
Care of plant	8.02
Repairs to plant	13.98
Towing	11.32
Miscellaneous expense	2.79
Total	353.80

Work done: 52 squares; cost per square, $6.80.
Material used per square: Brush, 1.42 cords; stone, 1.92 long tons; wire strand, 9.60 pounds.

Paring bank.

Labor and subsistence	$1,302.23
Stone, 2,319.31 long tons	3,132.30
Oils and engineer's supplies	19.76
Miscellaneous materials	90.56
Grading bank by hand	102.61
Superintendence	450.45
Care of plant	313.16
Repairs to plant	545.09
Towing	558.35
Miscellaneous expense	108.86
Total	6,623.40

Work done: 7,764 square yards; cost per square yard, $0.853.
Material used per square yard: Stone, 0.296 long tons.
Total field cost of Memphis Harbor work, $27,824.59.
Linear feet of bank revetted, 1,220; cost per linear foot, $22.81.

Subsistence.

Construction work: Rations issued, 2,084; cost per ration, raw, $0.3251; cost per ration, served, $0.4866.

Cost of stores	$667.62
Cost of services	337.42
Total cost	$1,015.04

Towing steamer *Graham:* Rations issued, 585; cost per ration, raw, $0.5062; cost per ration, served, $0.6088.

Cost of stores	$296.13
Cost of services	60.00
Total cost	356.13

DREDGING OPERATIONS IN WOLF RIVER.

The work was done by hired labor with a dredge purchased in July, 1898, from William A. Kirk for $8,000, and is the same that Mr. Kirk used in dredging Wolf River in 1897 under a yardage contract with this office.

The following is a brief description of the dredge:

Hull is 80 feet long, 28 feet wide, and 5 feet depth of hold; has a full length cabin, three spuds, a stiff leg A frame, a wooden boom 35 feet long with swinging radius of 29 feet, and can dredge to a depth of 12 feet. The dipper is of steel, with four steel teeth, and has 1¼ cubic yards net capacity. Winding engines are Barnhart's patent, made by the Marion Steam Shovel Company, with two cylinders 9½ by 11 inches, one main hoist drum, one backing drum, two swinging drums, and three spud hoist drums; all drums have cone friction, paper faced. Boiler is locomotive fire-box type, 50 horsepower nominal rating.

On July 5, when the Memphis gauge read 18 feet, a series of channel soundings were taken in Wolf River extending from the mouth to 2½ miles upstream. These, reduced to the zero stage of the Memphis gauge, showed depths as follows:

From the mouth to the railroad incline, at Station 20, depths below zero stage, 1 to 4 feet.

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From Station 20 to Station 40 (mouth of Bayou Gayoso), depths 6 feet, except just below Bayou Gayoso, where for a short distance the depth was 3 feet.

From Station 40 to Station 47 (mouth of Loosa Hatchie River), depths, 6 to 11 feet.

From Station 47 to Station 57 (lower end of Moore & McFerren's sawmill), depths, 3 to 4 feet.

From Station 57 to Station 75 (old waterworks incline), depths, 6 to 8 feet.

From Station 75 to Station 80, depths, 1 to 4 feet.

From Station 80 to Station 86, depths, 1 to 5 feet.

From Station 86 to Station 100 (railroad bridge), depths, 1 to 4 feet.

From Station 100 to Station 121, average depth 3 feet.

From Station 121 to Station 125, average depth 6 feet.

From Station 125 to Station 133 (upper limit of dredging), average depth, 2 feet.

There was no extreme low water during the working season and no runouts; the river bottom changed but slightly. When the river was at its lowest stage, viz, 4.6 feet on October 12, there was a minimum depth of 4 feet on the shoal places between Stations 0 and 20, and the same depths over the shoal places above the railroad bridge. All other localities had greater depths.

The stages of the river during the period covered by dredging operations are shown by the following readings of the Memphis gauge, viz:

	Feet.		Feet.
July 22	10.5	October 5	7.2
July 29	7.8	October 12	4.6
August 10	10.7	October 16	6.9
August 13	11.6	October 23	5.1
August 21	19.2	October 31	8.8
September 1	9.0	November 1	9.0
September 10	5.7	November 5	11.5
September 15	9.3	November 13	7.3
September 21	7.0	November 22	12.6
September 23	7.5	November 29	10.2
September 29	5.7		

The low-water stage was therefore much above the average, which is less than 2 feet.

The river was at a navigable stage during the entire working season for boats drawing 4 feet, which is about the maximum draft of boats using this stream. The channel, however, was in places narrow and crooked, and relief was afforded by dredging at these localities.

Work was begun on July 22 above the railroad bridge, and the first week was spent in training the crew and making some necessary changes to the machinery. Dredging was continued in this locality until August 13, when, the river becoming too high, work was suspended until the end of the month.

About 1,200 linear feet of channel was dredged between Stations 101 and 113, and the material, which was coarse sand mixed with gravel, was deposited on each side of the cut. Three thousand one hundred and thirty-four dipper loads were handled here, equal to about 3,350 cubic yards, and in addition 8 snags, 10 saw logs, and 4 piling were removed.

The river having fallen to a proper dredging stage, the dredge was dropped to the mouth of the river and work resumed on August 31. Soundings taken the preceding day with the Memphis gauge reading 10 feet gave depths of 8 feet at the mouth, increasing to 12 feet at Station 20, and indicating that during the recent rise a fill of about 3 feet had occurred at and near the mouth.

During the months of September and October dredging operations were confined to that portion of the river between the mouth and Station 20, and a well-defined channel was made about 75 feet wide 5 feet deep below the zero stage and about 1,800 feet long. Twenty-five thousand four hundred and fifty-one dipper loads, equal to about 37,000 cubic yards of material, were handled, and 2 snags and 2 saw logs were removed. Owing to the short swing of the dipper, from 2 to 3 cuts were made on each side of the center line to obtain a proper channel width. It is safe, therefore, to estimate that but little over half of the above volume, or 20,000 cubic yards, was removed from the cut and dumped on the sides. The material, in general, was a fairly stiff mud mixed with some sand and dredged well, filling the dipper to the bail. For each dredging hour worked about 78 cubic yards, measured in the dipper, were handled, and very little time was lost in repairs.

The work at the mouth having been completed, the dredge was removed to Station 113, above the railroad bridge, where a channel was dredged to Station 121. On November 7 work was suspended on account of a rising river, but resumed on the 14th at Station 125 and the channel dredged and snags removed up to Station 133, which was the upstream limit of the season's work, and where work was finally suspended on account of too high water on November 29.

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Many of the snags were so firmly embedded that they could not be removed by the dredge until loosened with charges of dynamite. The material dredged consisted of coarse sand mixed with gravel. Three thousand six hundred and seventy-seven dipper loads, equal to about 5,500 cubic yards, of material were dredged, and 58 snags, 5 stumps, and 3 saw logs removed between Stations 113 and 133. The following is a summary of work done:

Number of dipper loads	32,262
Cubic yards handled by dipper	45,850
Cubic yards removed from dredged channel as completed	28,850
Snags removed	68
Stumps removed	5
Saw logs removed	15
Piling removed	4

The cost of the work was—

For labor running dredge	$1,509.42
For labor repairing dredge	406.12
For coal	293.88
For material and supplies	91.32
For oils and engineer supplies	26.39
For ice	13.70
	2,340.82

Cost per cubic yard for material handled, about 5 cents; cost per cubic yard for material removed, about 8 cents.

HELENA, ARK.

By act of Congress July 1, 1898, the sum of $30,000 was appropriated for work at this harbor.

The project as made and executed was: To repair damage done to existing work during the floods of 1897 and 1898, and to further extend the work downstream along a caving bank.

The first bank-protection work in this harbor was done in 1889, when 1 mattress and 4 spur dikes were placed and a sill for the fifth dike sunk, this work protecting about 2,500 linear feet of the bank.

In 1896 the work was extended downstream by placing 1,600 linear feet of fascine mattress and revetting the upper bank with a stone paving. During the past season repairs were made to the old work and the fascine mattress and stone paving revetment was extended downstream 926 linear feet, so that now the work has a total length of 5,026 feet.

Prior to beginning the season's work the condition of the old work was about as follows:

Between dikes Nos. 1 and 2 a cave had occurred about 200 feet in length and 60 feet in width, and a similar cave had occurred between dikes Nos. 2 and 3. These dikes were built in 1889 and had afforded good protection until the high water of 1897. They were spaced 400 feet apart and built on sill mattresses 200 feet long, leaving an unrevetted space of 200 feet length between them. The depth along these unrevetted spaces had considerably increased, causing the caving. The repairs made comprised the revetting of these spaces with fascine mattresses 175 feet wide, and placing on them, and midway between the old dikes, new spurs of sufficient height and length to restore the slope to its normal condition, and thus break up the increased eddy action due to the caved pockets.

At Dike No. 4 the shore end had been undermined by the current, causing extensive settling of the crib work and a caving of the top bank. This was repaired by building a brush crib to connect the part of the dike in place with the top of the bank and paving over the brush work with stone.

Dike No. 6, situated at the extreme lower end of the 1896 work, was entirely above the low-water contour, and was built across a depression to break up eddy action there. Its lower portion, resting on a soft foundation and having settled greatly, was torn up and replaced with new brush work of much larger dimensions.

The fascine mattress and stone paving work of 1896 was all in good condition, having escaped injury from the large floods of 1897 and 1898, although subjected to very strong currents.

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The extent of repair work done was:

		Cubic feet.
Dike No. 1¼.	Sill mattress, 190 by 175 feet, 322 squares	32,200
	Crib, 180 feet long, 22 feet bottom width, 8 feet top width, 10 feet maximum height	20,540
Dike No. 2¼.	Sill mattress, 216 by 175 feet, 378 squares	37,800
	Crib, 190 feet long, 22 feet bottom width, 8 feet top width, 10 feet maximum height	22,440
Dike No. 4.	Crib, 100 feet long, 40 feet bottom width, 4 feet top width, 11.6 feet maximum height	12,696
Dike No. 6.	Crib, 130 feet long, 35.5 feet bottom width, 6 feet top width, 10.5 feet maximum height	18,773
	Total volume repair work	144,449

NEW WORK.

A fascine river mattress 976 feet long by 250 feet wide was placed at the lower end of the 1896 work, lapping it 50 feet, and extending the revetment downstream 926 feet. To join this with the shore, two connecting mattresses were required, their area being 213 squares. The bank was then graded and paved. The upstream portion of the mattress, for a length of over 500 feet, was along a ridge formed by a large bank slide. Inside of the ridge is a depression, and then a gradual slope to the top. Along this locality the paving was carried to the top of the ridge, an elevation of about 18 feet on the Helena gauge, and two spur dikes, Nos. 7 and 8, were built across the depression, connecting the crest of the ridge and top of bank. From Dike No. 8 to the lower end of the river mattress, a length of 420 feet, there was a very bluff bank, which was graded by the hydraulic method and then paved to the 28-foot stage.

At a location 500 feet above the head of the river mattress a spur dike, No. 5½, was built across a depression, connecting a ridge near the low-water line and the top of the main bank.

All spur dikes were of brush, built up with fairly regular side slopes, and paved with stone about 1 foot thick.

The extent of the new work was:

River mattress, 976 by 250 feet	squares	2,440
Connecting mattress	do	213
Dike No. 5½, crib, 177 feet long, 54 feet bottom width, 6 feet top width, 16 feet maximum height	cubic feet	40,783
Dike No. 7, crib, 110 feet long, 20 feet bottom width, 4 feet top width, 6 feet maximum height	cubic feet	6,744
Dike No. 8, crib, 125 feet long, 22 feet bottom width, 4 feet top width, 5 feet maximum height	cubic feet	5,720
Total volume of new crib work	cubic feet	53,247

The summary of work done is as follows:

River mattress	squares	2,440
Connecting mattress	do	213
Spur dikes, including sills, 197,696 cubic feet	cubic yards	7,322
Bank paved	square yards	5,917
Bank graded, 420 linear feet	cubic yards	8,130

The plant was moved to Helena upon the completion of the Memphis Harbor work, the last tow arriving November 16. As the river at that time was about the 12-foot stage and rising rapidly, the river mattress was not started, but instead, the sill mattress and cribs of Dike No. 1¼ were built.

The river reached the 18.8-foot stage on the 23d, then began to fall, and on the 29th work on the river mattress was begun, and the mattress was finished and sunk on December 16. Connecting mattresses were then placed, and work on the spur dikes and paving begun, advantage being taken of the lower stages of the river to put in the low-water work, completing the higher work as the river rose. By this method, and working at several places at the same time, all the work was successfully completed on January 11, and the last tow of plant delivered at the Memphis headquarters on January 25, 1899.

While the work was in progress the stages of the river were: November 16, 12.4 feet; November 23, 18.8 feet; December 12, 10.9 feet; December 23, 9.9 feet; January 4, 22.2 feet; January 11, 20.7 feet. Out of forty-six working days five and a half were lost by rain. The labor employed was both white and colored, subsisted and self-subsisted. The wages paid were 90 cents per day of eight hours,

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with subsistence, and $1.20 per day without. Brush and poles were obtained from the same contractors as at Memphis, and at the same price, the source of supply being about 20 miles above the work. Stone was loaded on United States barges at West Memphis at $1.36 per cubic yard, or per long ton of 2,240 pounds, and towed by contract to Helena at 22 cents per cubic yard, the contractor towing empty barges back to Memphis.

The details of cost, cost per unit, and material used per unit are as follows:

River mattress.

Labor and subsistence	$3,915.38
Brush, 3,441.4 cords	3,579.06
Poles, 201 cords	301.50
Stone, 1,425 long tons	2,251.50
Wire strand, 25,465 pounds	648.95
Wire, galvanized, No. 12, 4,000 pounds	66.00
Wire, silicon bronze, No. 9, 1,000 pounds	135.00
Clips, 4,034	180.05
Rope, manila, 2,000 pounds	191.40
Miscellaneous materials	80.67
Superintendence	541.80
Care of plant	654.69
Repairs to plant	262.13
Towing	1,212.44
Miscellaneous expenses	110.03
Total	14,130.53

Work done: Mattress 976 by 250 feet, 2,440 squares; cost per square, $5.79.

Material used per square: Brush, 1.41 cords; poles, 0.082 cord; stone, 0.58 long ton; one-fourth inch wire strand, 6.36 pounds; five-sixteenth inch wire strand, 3.20 pounds; one-half inch wire strand, 0.865 pound; wire, galvanized, No. 12, 1.64 pounds; wire, silicon bronze, No. 9, 0.409 pound; clips, 1.65.

Connecting mats.

Labor and subsistence	$652.36
Brush, 200 cords	208.00
Poles, 22.9 cords	34.35
Stone, 200.74 long tons	317.17
Wire strand, 1,000 pounds	26.35
Wire, galvanized, No. 12, 450 pounds	7.42
Clips, 200	7.96
Superintendence	67.72
Care of plant	81.60
Repairs to plant	32.77
Towing	151.23
Miscellaneous expenses	13.76
Total	1,600.69

Work done: 213 squares; cost per square, $7.51.

Material used per square: Brush, 0.94 cord; poles, 0.11 cord; stone, 0.94 long ton; one-fourth inch wire strand, 4.70 pounds; five-sixteenths inch wire strand 2.11 pounds; clips 0.94.

Crib dikes (including sills).

Labor and subsistence	$3,725.49
Brush, 1,642.8 cords	1,708.51
Poles, 371.5 cords	557.25
Stone, 1,400 long tons	2,212.00
Wire strand, one-fourth inch, 2,750 pounds	72.46
Wire, galvanized, No. 12, 1,000 pounds	16.50
Clips, 200	7.96
Rope, manila, 2,000 pounds	191.40
Miscellaneous material	6.80
Superintendence	474.07
Care of plant	570.38
Repairs to plant	229.37
Towing	1,057.37
Miscellaneous expense	96.27
Total	10,925.78

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Work done: 7,322 cubic yards; cost per cubic yard, $1.49.
Material used per cubic yard: Brush, 0.224 cord; poles, 0.051 cord; stone, 0.19 long ton; one-fourth-inch wire strand, 0.375 pound; galvanized wire, No. 12, 0.137 pound; clips, 0.027.

Paving bank.

Labor and subsistence	$1,073.20
Stone, 2,017.13 long tons	3,177.58
Hydraulic grading, 8,130 cubic yards, at $0.0516	420.22
Superintendence	270.90
Care of plant	325.51
Repairs to plant	131.06
Towing	603.68
Miscellaneous expense	55.00
Total	6,057.15

Work done: 5,917 square yards; cost per square yard, $1.02.
Material used per square yard: Stone, 0.34 long ton.
Total field cost of Helena Harbor work, $32,714.15.

Cost of subsistence.

Construction party: Rations issued, 10,118; cost per ration raw, $0.2452; cost per ration served, $0.3242.

Cost of stores	$2,456.25
Cost of services	791.88
Total	3,248.13

Steamer *Graham:* Rations issued, 790; cost per ration raw, $0.4571; cost per ration served, $0.6005.

Cost of stores	$361.11
Cost of services	113.33
Total	474.44

Of the 5,026 linear feet of revetment at Helena Harbor the lower 4,000 feet affords good protection. The upper 1,000 feet consists of a river mattress 600 feet long by 226 feet wide, without upper bank protection, and below this an unrevetted space of 400 feet, extending to the head of Spur Dike No. 1.

Recent caving has occurred here, extending from just above Dike No. 1 upstream a distance of about 600 feet, with 60 feet maximum width of caving, and about 40 feet average width.

In view of the importance of the locality, situated as it is at the head of the revetment work, this caving should be stopped by building a strong revetment along the attacked bank. Such a revetment could be made with fascine mats 250 feet wide, and grading and paving the upper bank. The probable length required will be 700 linear feet, and estimated cost $20,000.

Very respectfully,

W. M. REES, *Assistant Engineer.*

Capt. E. EVELETH WINSLOW,
Corps of Engineers, U. S. A.

REPORT OF MR. CHARLES LE VASSEUR, ASSISTANT ENGINEER, ON WORK OF REMOVING NONCONNAH ROCK, BELOW MEMPHIS, TENN.

MEMPHIS, TENN., *April 30, 1899.*

CAPTAIN: I have the honor to submit the following report on the operations at Nonconnah Rock from September 15 to November 18, 1898:

The object of the work was the destruction, by submarine drilling and blasting, of the part of Nonconnah Rock left standing after the operations conducted in 1896-97.

Nonconnah Rock is situated 4 miles below the Memphis Railroad Bridge and 700 feet from the Tennessee shore. This rock is a composition of a ferruginous sandstone and cemented gravel, and has been a serious obstruction to boats with heavy tows, owing to its location in the channel.

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On September 10, 1898, I made a survey of said rock with a view to ascertaining its exact location and the depth of water over it. The result of this survey, shown on the map accompanying this report, indicates that an area of 22,000 square feet of rock was under a depth of water varying from 7 to 8 feet below the zero of the Memphis gauge.

On September 15 the force was organized and the plant overhauled and put in working condition. On September 22 the plant was towed from the United States fleet to the site of the work.

The plant consisted of a drilling platform and pontoons, a flat barge 50 by 15 feet, on which was hoisting machine, pump, and boiler, mounted; one mooring barge, two flats, and quarter boat *Mississippi*. The U. S. S. *H. L. Abbot* was used as a tender.

The drilling platform, which was built especially for this work in 1896, was composed of a floor or platform on which drilling machine was placed and worked. This floor was provided at each end with one spud 20 feet long, 10 by 10 inches, running through a well. To this platform was framed an overhead truss, used for handling drilling tools and pipes and for raising and lowering said tools and hydraulic jet pipe. The platform was floated on two pontoons, lashed lengthway to the floor frame.

The machinery flat was fitted with a Knowles tank pump, 6-inch plunger, a steam winch, and a small upright boiler. The steam necessary for the steam drill was furnished by said boiler.

The force employed was composed of 1 foreman, 1 steam-drill engineer, 1 hoisting steam engineer, 1 blacksmith, 1 cook and waiter, and 16 laborers.

The foreman was to be employed as diver if submarine observations would be necessary.

The method of operation was the same as described in my annual report for the fiscal year 1896–97. (Report of Chief of Engineers, p. 3721.)

The mooring barge was anchored by means of wire cables and Chinese anchors 500 feet above the upstream edge of the rock. From this mooring barge, with the aid of the steam winch, flats, machine barge, and drilling platform were swung into position. The mooring barge was so located that the whole area of the rock could be covered by taking in or paying off on two side cables leading from it to the platform. The drilling platform, floating on pontoons, was dropped by said process over the exact part of the rock where drilling operations were to be conducted, the spuds lowered down, and the platform raised on spuds by means of rope and tackle wound on drum of hoisting machine, or by ratchet fixed to spuds and floor of platform.

The location of the platform was ascertained by instrumental observations from shore. As soon as the platform was raised soundings were taken every 5 feet over the space covered by said platform and compared with soundings of the survey made September 10, 1898. If differences in soundings were shown, said differences were noted on map.

An iron pipe 4 inches in diameter and of a length sufficient to project 1 foot over the surface of the water was placed on top of rock, rammed down as far as possible, and made fast by four lines leading at different angles to the floor timber of platform. This pipe was to prevent the hole to be drilled from being filled by sand or sediment. The drilling tool, 2¼ inches in diameter, was placed inside the 4-inch iron pipe, the drilling machine shipped up over said pipe and connected to tool, and drilling operations started. The holes were drilled to an average depth of 4½ feet.

When the first hole was drilled the machine was moved over a second 4-inch pipe placed (as above described) during the first drilling operation. The first hole was then washed by hydraulic jet set inside of the 4-inch iron pipe, and a cartridge, composed of 4½ pounds of dynamite, with proper exploders and insulated electric wires attached, was rammed to the bottom of the hole through the same 4-inch pipe and said pipe raised up. These operations were continued all day. At the end of the working day the platform and machinery barge were hauled up near mooring barge and loaded holes exploded by electric battery.

In the morning of the next day survey was made over the area blasted the evening before and soundings taken and plotted on working sheet. At the end of the month survey was made to obtain the total amount of rock destroyed. At the end of the work soundings were taken over the area of the rock. Map accompanying this report shows these soundings.

From the examination of said map 25,000 square feet of rock were found to have been disturbed and 2,314 cubic yards of rock destroyed.

On November 17 the operations were completed and the plant towed back to the United States fleet. The least depth of water over the rock was 7 feet above zero, Memphis gauge.

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The cost of the operations at Nonconnah Rock is as follows:

Labor and subsistence	$1,625.01
Subsistence (services and stores)	427.24
Dynamite	155.60
Wire, insulated, and exploders	36.40
Coal	87.25
Oil and engineer's supplies	50.00
Plant (miscellaneous)	80.00
Total	2,461.50

making a cost of $1.063 per cubic yard of rock destroyed.

I have the honor to transmit herewith a tracing of surveys made on September 10 and November 18, 1898.

Respectfully submitted. CHAS. LE VASSEUR, *Assistant Engineer.*

Capt. E. EVELETH WINSLOW,
Corps of Engineers, U. S. A.

REPORT OF MR. AUG. J. NOLTY, ASSISTANT ENGINEER, ON CARE OF AND REPAIRS TO PLANT, FIRST AND SECOND DISTRICTS, IMPROVING MISSISSIPPI RIVER, FOR THE YEAR ENDING APRIL 30, 1899.

MEMPHIS, TENN., *April 30, 1899.*

SIR: I have the honor to submit my report of the operations of, the care of, and repairs to plant party for the year ending April 30, 1899.

Steamer Chisca.—A condensing apparatus for furnishing clear water for culinary and other purposes was installed on this boat, everything pertaining thereto having been fabricated on the fleet. The boat was also supplied with a complete set of siphon pipes and fittings. One new rudder stock was put in and minor repairs, such as replacing broken fenders, patching deck and roof, were made from time to time.

Steamer Titan.—This boat was received back from the third district, where it had been employed in towing stone, on June 25. It was then found necessary to rebuild the furnaces. The four forward hog-chain braces were found to be badly decayed from the main deck down; these were successively spliced out and the chains jacked back to their original position. The decayed footings of the braces were also repaired. A cracked flange on the port leg of the forward mud drum was repaired with a new flanged sleeve, and a corroded place on the drum itself was repaired with a patch. On August 25 the boat was placed in commission and left the same day with a tow on construction plant for New Madrid, Mo. In taking a short cut across a bar just below Hales Point, Tennessee, it was found that the boat was getting into shoal water, and in attempting to get into deeper water the boat was backed upon a submerged stump, which tore up the bottom and caused the boat to sink in 6 feet of water. As the river was falling at the rate of 1.5 feet in twenty-four hours, it was evident that nothing could be done to float the boat on the then existing stage of water. An examination showed that the bottom was torn up for a length of 48 feet and for a width nearly equal half the molded beam. A bulkhead was at once built around the damaged bottom, with the intention of towing the boat on the first rise to some marine ways for repairs. The river continuing to fall and the boat having sunk at quite a high stage of river, it was finally decided to repair it where it sank as soon as the bar had drained sufficiently to permit excavating the necessary working pit under the damaged bottom. Repairs were begun on October 13 and completed on the 31st of that month. The repairs were well done, as was proven when the boat was floated off, which was on the 29th of December.

As the boat required new cylinder timbers, new hog-chain braces, and chain keelsons, besides repairs to portions of the bottom not previously repaired, and as our dock is unserviceable, a contract for docking and repairing the boat was entered into with the American Boat Works, of St. Louis, Mo., and the boat delivered to this firm on March 18.

Steamer H. M. Graham.—An ice chest and refrigerator has been built into this boat, a full set of syphon pipes has been supplied, new packing rings fitted into pistons of main engines, valve gear has been repaired, "nigger engine" repaired, together with other minor repairs.

Tug Itasca.—During a squall on the night of July 21 this boat was swamped at her anchorage, and sank in 32 feet of water. On August 13 the boat was again afloat, but with part of her cabin demolished and wheel badly damaged. As the standing

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part of the upper works was very old and much decayed, it was decided to build an entirely new cabin. The wheel was repaired, new stack made, and boat painted inside and out.

Launch H. L. Abbot.—One new sheet was put into the boiler of this boat. It also received minor repairs from time to time and was painted throughout.

Dredge Wolf.—Some repairs were made to the shears of this machine, four trusses—one under boiler and three under engines—were placed below deck, and so designed as to carry some of the strains, due to weight, to the two gunwales. The rake of the boat having sprung away from its intended position, by reason of the weight of the forward spud, three heavy tie-rods were run from the gunwales and the bulkhead in such a manner as to bring the rake back to its original position and hold it there. The machinery was overhauled, hull calked, deck repaired, new chain rack made. Cold shuts, shackles, spud pins, bolts, etc., were made from time to time as required.

During the progress of dredging Wolf River the necessity of a longer boom and dipper became apparent, and it was decided to lengthen the former 10 feet and the latter 6 feet. This involves the raising of the shears 5 feet. This work is now in progress. A new cast-steel lip for the dipper will also be made, the old one being broken. All worn pins, gudgeons, bearings, and other parts of the machinery will be repaired.

Hydraulic graders.—At the date of my last report grader No. 2 was on the dock undergoing repairs that practically amounted to a new hull, nothing but the bulkheads being in such a condition as to render their retainment in the new hull permissible. The pumping machinery and auxiliary engines were thoroughly overhauled and the entire machine put in good working condition. A bursted water chamber on one of the 16-inch pumps should be replaced with a new one in time for the coming season's work.

Grader No. 40 was overhauled preparatory to being sent out; the hull was calked and two new stacks erected.

Pile drivers.—There are two of these now here, Nos. 19 and 20. Each received a new stack, had hulls calked, leads repaired, etc.

Outfit for removal of Nonconnah rock.—In former operations on this ledge a pile driver was used to supply steam to drill and pump. By reason of the transfer of one pile driver to the secretary of the Mississippi River Commission, no machine of this kind could be spared for the work. A 50-foot flat was therefore fitted with a 5-horsepower vertical boiler, a 6-inch Knowles tank pump, a steam winch, and the necessary feed pump, heaters, etc. This furnished all the steam and water necessary.

Barges, model.—There are ten of these, built in 1894. Each one was docked, and besides being calked all around, received such patches to hull and deck as was necessary.

Barges, gunwale.—Twenty-nine of these were built in 1893. Twenty-seven are now available, one having been wrecked by a landslide from the high bluff in front of which the barge was moored, and one being in use as hull to quarter boat; 9303, 9306, 9310, and 9321 being in the worst condition, were docked, calked all around, and otherwise repaired, so as to make them serviceable. Owing to the limited amount of funds, the others were calked while afloat and patched so as to make them fairly safe for the season's work. All require extensive repairs before they can be pronounced serviceable.

Barges, framed.—These were built in 1889 and rebuilt once since. There are ten of these, but two are in use as hulls to quarter boats 206 and 221, two as mooring barges, and two as fascine barges. These barges received such repairs as would make them serviceable for the season's work.

Quarter boats.—The roof covering of Nos. 206 and 221, consisting of *Defiance No. 2*, being worn out, it was decided to cover these roofs with galvanized-iron shingles. These were then coated with two coats of red mineral paint in boiled oil. Nos. 12, 25, 27, 39, *Amelia*, and *Mississippi* received repairs sufficient to put them in serviceable condition.

Mooring barges.—These had hulls calked and patched, new timber heads and kevils put on, decks repaired, and hog chains and tie rods refitted.

Fascine barges.—These were calked and otherwise patched to make them serviceable for the season. Three of these are now beyond repair.

Mattress barges.—There are six of these, but two are awaiting condemnation. All received only such repairs as would enable them to stand the season's work. Two will have to receive extensive repairs to fit them for future work. Two, to replace those to be condemned, are now being constructed out of two gunwale barges.

Fifty-foot flats.—Three of these were docked and repaired.

Floating dock.—This was built in 1889, and has been in service ever since, receiving comparatively little repair. With a view toward rebuilding it, it has been floated out on the bank and blocked up. The work of rebuilding is now in progress. The

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bottom strake all around floor and entire floor system and the end gates are still in prime condition, and will be retained. Everything above the bottom strake, however, will be renewed.

Plant reduction.—The serviceable plant has been reduced during the year by nine pieces, as follows: One machine-shop boat dismantled, 1 hydraulic grader (No. 4) no longer serviceable, 2 mattress barges unserviceable, 1 barge wrecked, 4 barges built in 1884 and once rebuilt, no longer serviceable. All but the first-mentioned piece have been recommended for condemnation.

Miscellaneous work.—A large amount of work, such as fabricating and repairing bilge pumps, fitting up chains, shackles, and pins for mat and mooring barges, making and repairing heavy cable clamps, repairing Haven clamps, making wire twisters, mauls, capstan bars, pike poles, coal boxes, repairing wheelbarrows, serving grader hose with canvas and marlin, making three new calking flats, etc., has been done.

Cost of, care of, and repairs to plant for the twelve months ending April 30, 1899.

Steamer *Chisca*	$496.50
Steamer *Titan*	1,315.30
Steamer *H. M. Graham*	328.59
Launch *H. L. Abbot*	110.20
Tug *Itasca*	780.50
Dredge *Wolf*	478.56
Hydraulic grader No. 2	318.55
Hydraulic grader No. 40	51.80
Pile driver No. 19	125.60
Pile driver No. 20	118.40
Steam tender for Nonconnah rock	114.46
Barges	5,121.60
Quarter boat No. 206	305.40
Quarter boat No. 221	305.40
Other quarter boats	441.65
Mattress barges	422.40
Floating dock	1,941.99
Care of plant	12,067.68
Tools and appliances	836.31
Miscellaneous	973.57
Total	26,654.46

Respectfully submitted.

AUG. J. NOLTY, *Assistant Engineer.*

Capt. E. EVELETH WINSLOW,
Corps of Engineers, U. S. A.

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Abstract of proposals for levee work in Lower St. Francis, White River, and Upper Yazoo Levee districts, received in response to public notice dated July 19, 1898, and opened August 10, 1898, by Capt. Mason M. Patrick, Corps of Engineers.

No.	Name and address of bidder.	Lower St. Francis Levee district.						White River Levee district.		Upper Yazoo Levee district, sections 61–82.
		Section 16.	Sections 26–31.	Sections 41–47.	Section 52.	Sections 61–87.	Sections 96–101.	Sections 4–14.	Sections 35–47.	
		Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
1	Thomas & Co., Memphis, Tenn.	.....	.....	.....	.....	.....	.....	.....	.....	16
2	W. H. Grider, Sans Souci, Ark.	.....	.....	.....	.....	a16	.....	.....	.....	.....
3	Cary & Johnsen, Memphis, Tenn. *b*	.....	15.99	15.99	15.99	15.99	15.99	14.99	14.99	15.49
4	C. H. Dameron, Huntsville, Mo	.....	.....	.....	.....	.....	.....	.....	.....	15½
5	Aderholdt & Lowrance, Friars Point, Miss	.....	.....	.....	.....	.....	.....	14½	.....	a14.94
6	Morrow & Carter, Memphis, Tenn. *c*	18	18	18	18	18	18	13.95	18	17.95
7	Luther Walker, Hickman, Ark	.....	.....	.....	13	.....	.....	.....	.....	.....
8	J. D. Montgomery, Durhamville, Tenn	11.95	16	15	a12½	17	a17	.....	.....	.....
9	P. Cassidy, Avenue, Ark	.....	.....	.....	.....	.....	.....	11½	.....	.....
10	W. H. Huffman, Caruthersville, Mo	13	14	15	.....	.....	.....	.....	.....	.....
11	Sessions & Bush, Friars Point, Miss	.....	.....	.....	.....	.....	.....	17½	17½	22½
12	E. B. Mantle, Memphis, Tenn	.....	.....	.....	.....	.....	.....	.....	22½	.....
13	Keeney & Bailey, Carbondale, Ill. *d*	13.45	13.45	13.45	13.45	22	22	.....	.....	.....
14	T. Mike, Greenville, Miss	a10½	a11	a14	.....	.....	.....	.....	.....	.....
15	J. E. Kerr, Paxton, Ill.	21	24	24	22	25	25	21	27	21½
16	Shippey & Kilpatrick, Memphis, Tenn	.....	.....	.....	.....	.....	.....	.....	.....	15.98
17	P. McCadden, Memphis, Tenn.	.....	.....	.....	.....	.....	.....	12.40	.....	17.70
18	John Scott & Sons, St. Louis, Mo. *d*	14.7	14.7	15.7	13½	15.7	15.7	.....	.....	.....
19	J. B. Reid, Stovall, Miss	.....	.....	.....	.....	.....	.....	13.45	.....	.....
20	Martin Jennings & Co., Memphis, Tenn	.....	.....	.....	.....	.....	.....	11½	.....	16½

a Accepted.
b Will take all or none of work in St. Francis or White River Levee districts.
c Will take all or none in St. Francis district.
d Will take all or none.

All bids for sections 35–47 in White River Levee district rejected.
Prices bid are per cubic yard.

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Abstract of proposals for furnishing brush, poles, stone, wire, wire strand, silicon-bronze wire, clips, staples, and manila rope, received in response to advertisement dated July 18, 1898, and opened by Capt. Mason M. Patrick, Corps of Engineers, August 18, 1898.

No.	Name and address of bidder.	Brush, per cord.	Poles, per cord.	Stone, per cubic yard. On contractors' barges at— New Madrid. Riprap.	New Madrid. Spalls.	Plum Point Reach. Riprap.	Plum Point Reach. Spalls.	Memphis. Riprap.	Memphis. Spalls.	Helena. Riprap.	Helena. Spalls.
2	R. Ligon & Co., St. Louis, Mo.	$1.19	$1.49	.....	.....	.....	.....	.....	.....	.....	.....
8	Hunter & Frey, Memphis, Tenn.	a1.04	a1.50	.....	.....	.....	.....	.....	.....	.....	.....
10	McDonald & Thompson, St. Louis, Mo	.79½	.99½	.....	.....	.....	.....	.....	.....	.....	.....
11	Oscar F. Barrett, Cincinnati, Ohio	.....	.....	$1.28	$1.28	$1.47	$1.47	.....	.....	.....	.....
15	Fred Hartweg, Cincinnati, Ohio	.....	.....	a1.18½	a1.9½	a1.33½	a1.24½	$1.48½	$1.39½	$1.63½	$1.54½

No.	Name and address of bidder.	Stone, per cubic yard. On Government barges at Memphis. Riprap.	On Government barges at Memphis. Spalls.	On bank at Helena. Riprap.	On bank at Helena. Spalls.	On Government barges at quarries. Riprap.	On Government barges at quarries. Spalls.	Galvanized wire No. 12, per pound.
						Cents.	*Cents.*	*Cents.*
2	R. Ligon & Co., St. Louis, Mo	a$1.36	a$1.36	$1.44	$1.44	47.9	47.9	.....
3	Livermore Foundry and Machine Co., Memphis, Tenn	.....	.....	.....	.....	.....	.....	1.8
4	Fred Hanger, Little Rock, Ark	.....	.....	1.55	1.55	.....	.....	.....
5	Harry E. Coffin, Memphis, Tenn	.....	.....	.....	.....	.....	.....	a1.65
6	George Skene, Memphis, Tenn	.....	.....	.....	.....	.....	.....	1.72
7	Edward Hely, Louisville, Ky	1.49	1.39	1.39	1.29	.....	.....	.....
10	McDonald & Thompson, St. Louis, Mo	1.61	1.61	1.90	1.90	59	59	1.92
13	M. M. Buck Manufacturing Co., St. Louis, Mo	.....	.....	.....	.....	.....	.....	1.8
16	Washburn & Moen Manufacturing Co., Chicago, Ill	.....	.....	.....	.....	.....	.....	1.8

No.	Name and address of bidder.	Wire strand. ⅜-inch, per pound.	Wire strand. ⅞-inch, per pound.	Wire strand. ½-inch, per pound.	Silicon-bronze wire, per pound.	Wire rope clips. ⅞-inch, each.	Wire rope clips. ½-inch, each.	Fence staples, per pound.	Manila rope, per pound.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Lee Brothers, Memphis, Tenn	.....	.....	.....	.....	8.14	11.23	.....	10.22
3	Livermore Foundry and Machine Co., Memphis, Tenn	2.9	2.45	.....	.....	.....	.....	a1.8	.....
5	Harry E. Coffin, Memphis, Tenn.	a2.63½	a2.36½	a2.48	a13½	a3.98	a6½	2	10.38
6	George Skene, Memphis, Tenn	2.72	2.42	2.57	19	7.79	10.54	2	a9.57
9	Schermerhorn Bros. Co., St. Louis, Mo	.....	.....	.....	.....	.....	.....	.....	9.7
10	McDonald & Thompson, St. Louis, Mo	3.14	2.82	2.91	17.9	8.68	10½	2½	10½
12	Fearing, Whiton & Co., Boston, Mass	.....	.....	.....	.....	.....	.....	.....	9½
13	M. M. Buck Manufacturing Co., St. Louis, Mo	.....	.....	.....	.....	7.94	10.69	.....	10
14	Hoffman, Corkran & Co., Philadelphia, Pa	.....	.....	.....	.....	.....	.....	.....	10
16	Washburn & Moen Manufacturing Co., Chicago, Ill	2.85	2.40	3.15	.....	.....	.....	.....	.....
17	Wm. M. Bird & Co., Charleston, S. C	.....	.....	.....	.....	.....	.....	.....	10

a Accepted.

NOTE.—Bids for stone "on contractors' barges" at Memphis and Helena, "on bank at Helena," and "on Government barges at quarries," not accepted, it being more economical and advantageous to supply stone for use at Memphis and Helena from stone delivered "on Government barges at Memphis."

Acceptance of bid of Hunter & Frey for brush and poles authorized by Chief of Engineers August 27, 1898.

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Abstract of proposals for levee work in White River Levee district received in response to public notice dated August 11, 1898, and opened August 17, 1898, by Capt. Mason M. Patrick, Corps of Engineers.

No.	Name and address of bidder.	Sections 25–47, per cubic yard.
		Cents.
1	Morrow & Carter, Memphis, Tenn	19
2	Martin Jennings & Co., Memphis, Tenn a	16
3	Bush Bros., Artonish, Miss	16½

a Accepted.

Abstract of proposals for teams, etc., for levee work received in response to public notice dated August 11, 1898, and opened August 20, 1898, by Capt. Mason M. Patrick, Corps of Engineers.

No.	Name and address of bidder.	Lower St. Francis Levee district.		White River Levee district.	
		Number of teams.	Hire each, per day.	Number of teams.	Hire each, per day.
1	Robert Johnson, Memphis, Tenn	10	$3.90	10	$3.9
2	Bush Brothers, Artonish, Miss			20	4.0
3	Ed. H. Williams, Luxora, Ark	10 to 15	a 2.85		
4	E. B. Mantle, Memphis, Tenn			18 to 20	4.0
5	Morrow & Carter, Memphis, Tenn			20	a 3.9
6	Harry N. Pharr, Memphis, Tenn	20	3.25		

a Accepted.

Abstract of proposals for levee work in Lower St. Francis Levee district, near Rosa, Ark., received in response to public notice, dated December 12, 1898, and opened December 20, by Capt. E. Eveleth Winslow, Corps of Engineers.

No.	Name and address of bidder.	From Station 59 toward old levee, per cubic yard.
		Cents.
1	Elliott Williams, Luxora, Ark	12
2	Ed. H. Williams, Luxora, Ark	12½
3	W. C. Rozell, Rosa, Ark	a 14½

a Accepted.

Abstract of proposals for levee work in Lower St. Francis Levee district, near Rankin Mills, Mo., received in response to public notice, dated December 20, 1898, and opened December 30, 1898, by Capt. E. Eveleth Winslow, Corps of Engineers.

No.	Name and address of bidder.	From Station 14 toward Wolf Bayou, per cubic yard.
		Cents.
1	Stokley Jacobs, Gayoso, Mo	a 1
2	Andy Lafferty, Stewarts, Mo	1

a Accepted.

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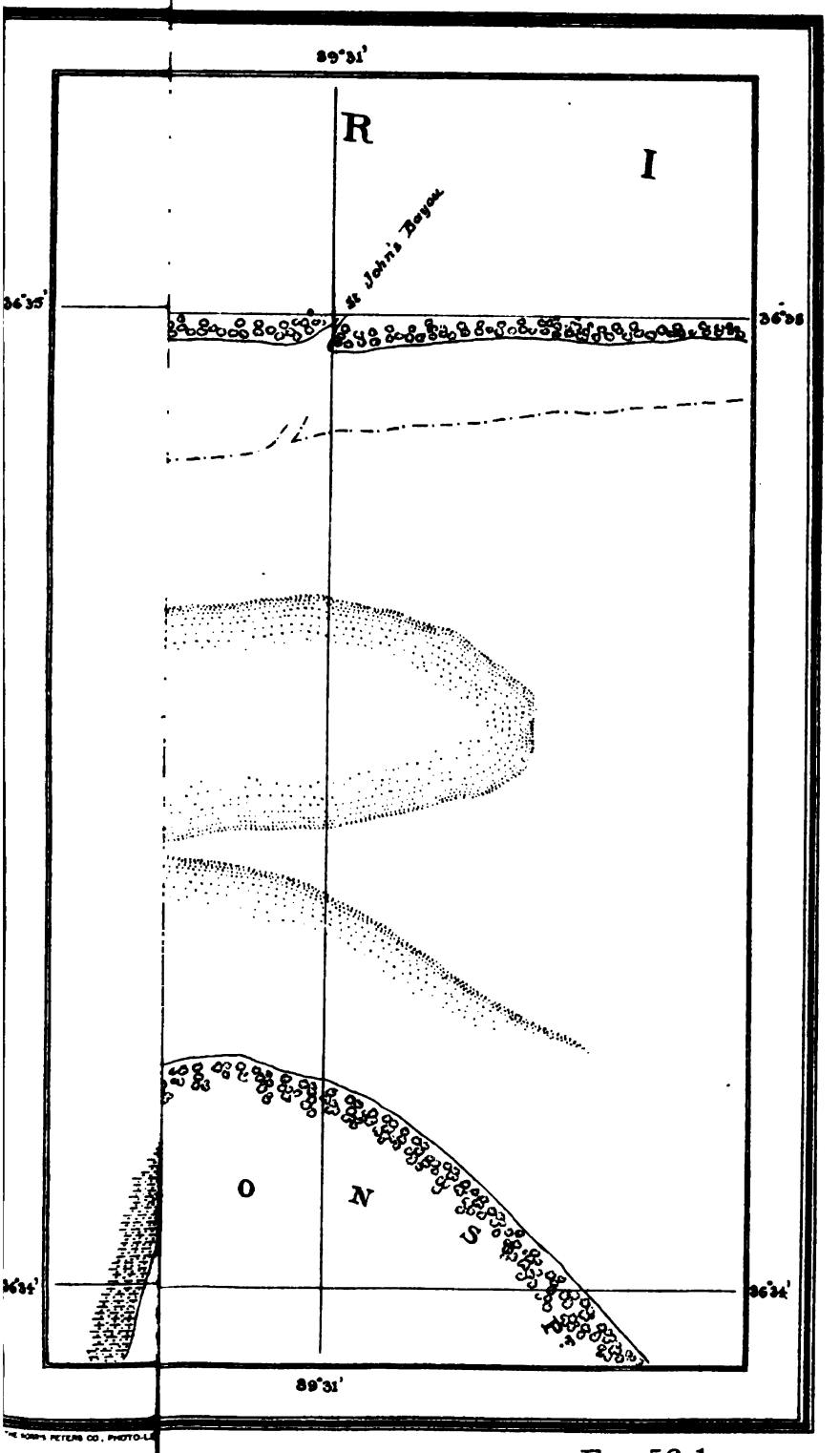

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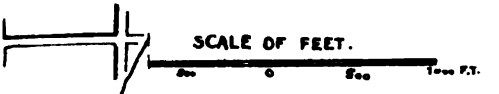
made under the direction of

tain E.E. WINSLOW,

Corps of Engrs. U. S. A.

Pt PLEASANT, Chas. LEVASSEUR, U.S. Ass't Engr.



To accompany my annual report for the fiscal year ending June 30, 1899.

E. Eulett Winslow

Captain of Engrs U.S.A.

36°27'

36°27'

Canal

Represents anchor pills 30' apart

" reversed abutts.

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Note: The contour lines are from survey made Sept 27th 1898.

THE ROBERT PETERS CO. PHOTO

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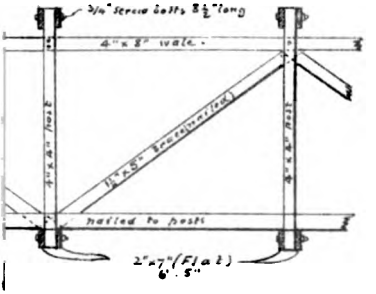

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To accompany my annual report for the fiscal year ending June 30. 1899.

L. Elliott Wimsatt

Captain of Engr's. U. S. A.

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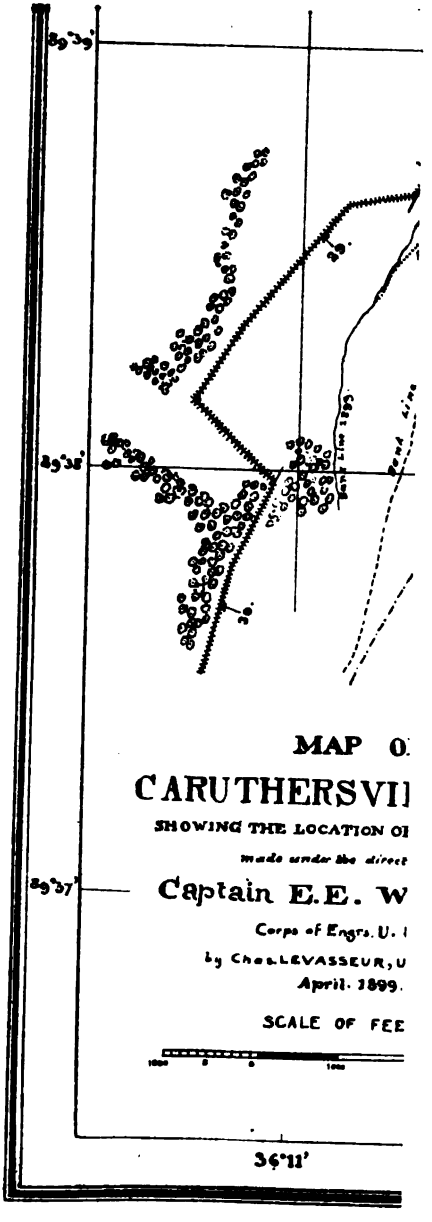

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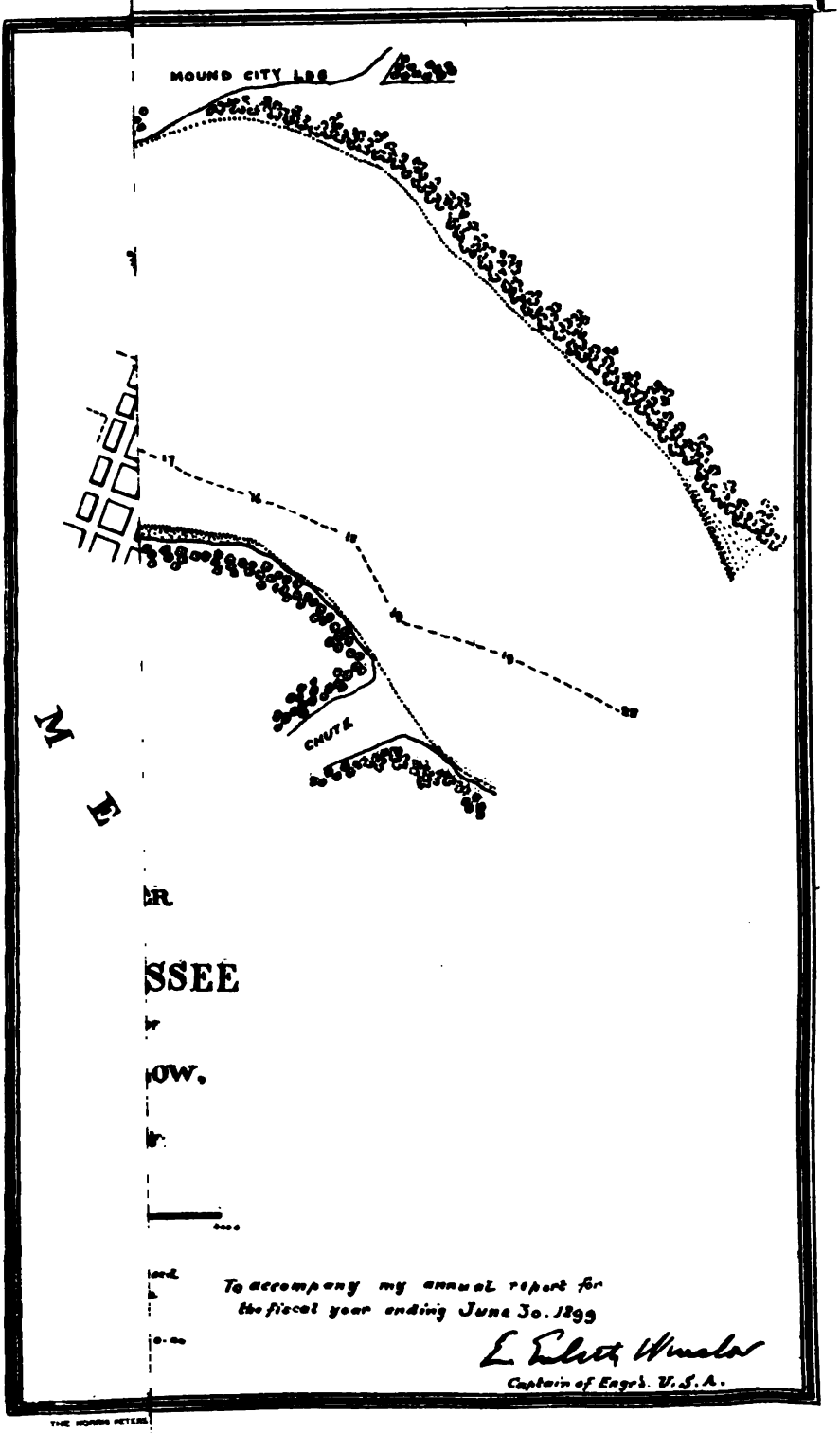

To accompany my annual report for the fiscal year ending June 30. 1899

E. Elliott Wheeler
Captain of Engrs. U.S.A.

THE HOBBS PETERS

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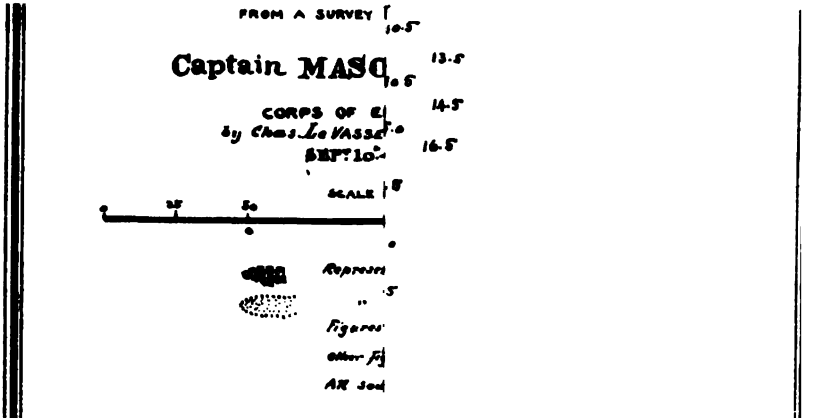

THE HOBBS PETERS CO. PHOTO-LITHO WASHINGTON D C

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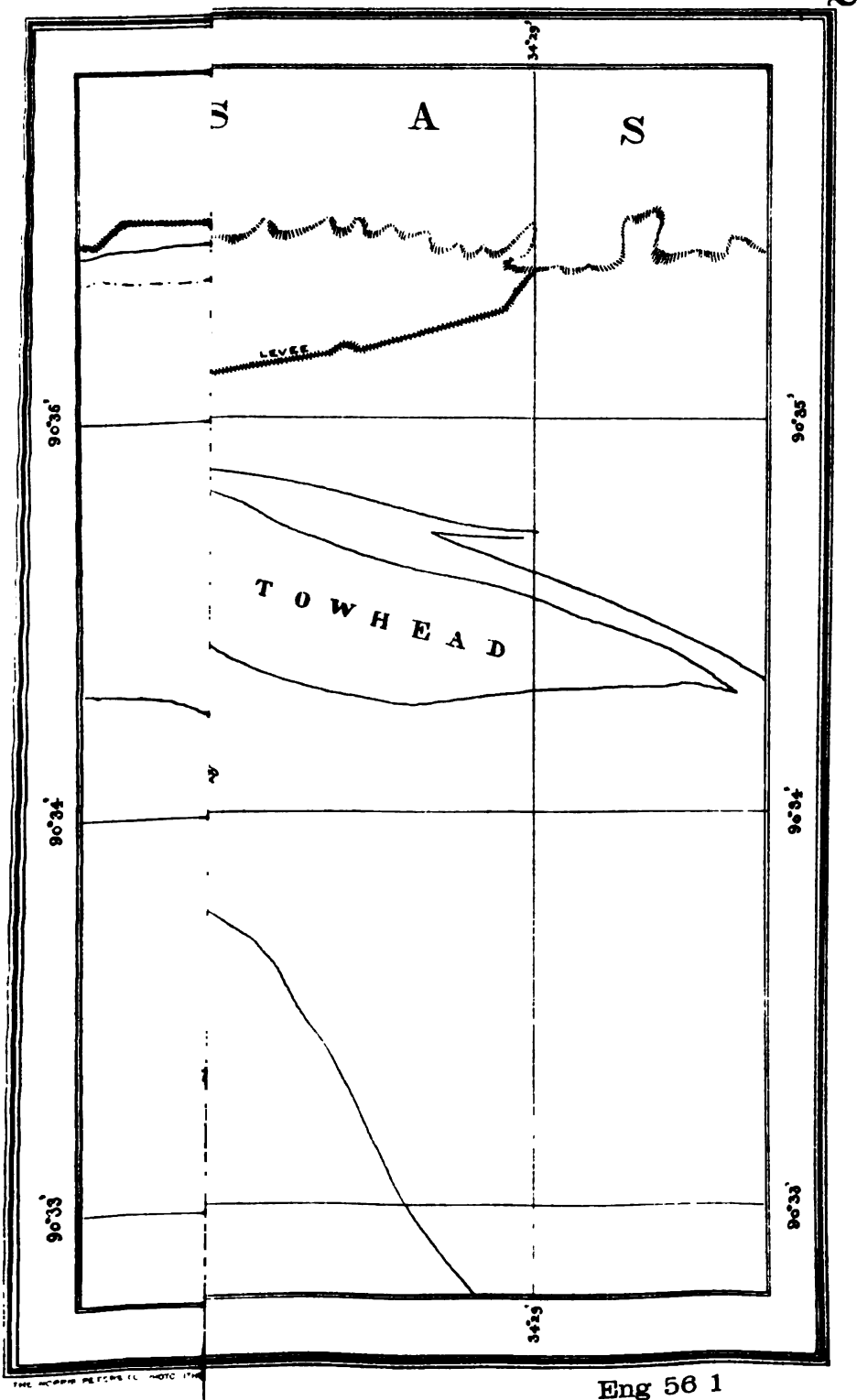

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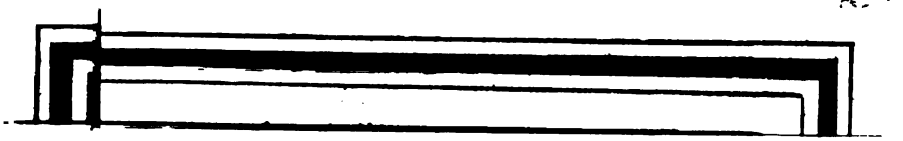

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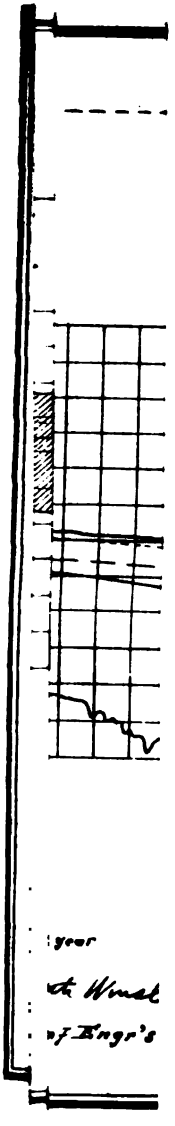

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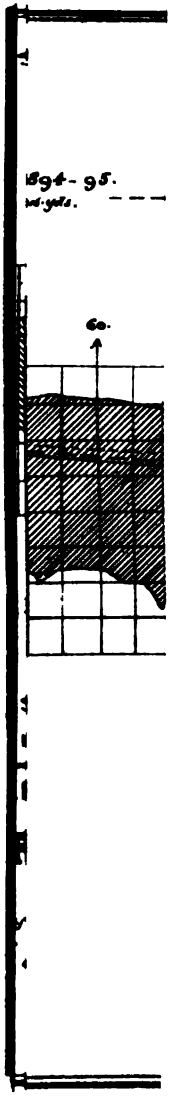

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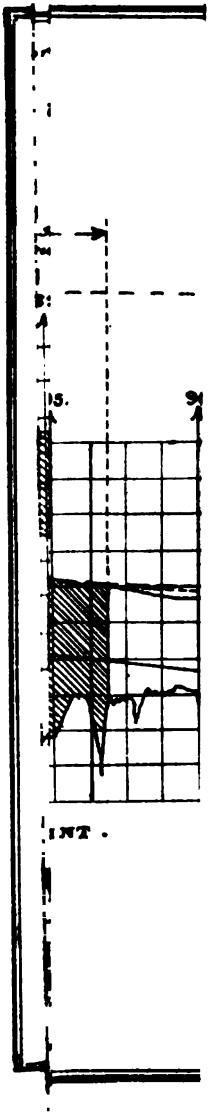

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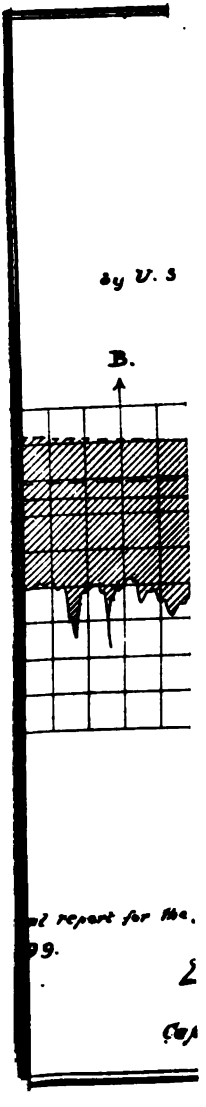

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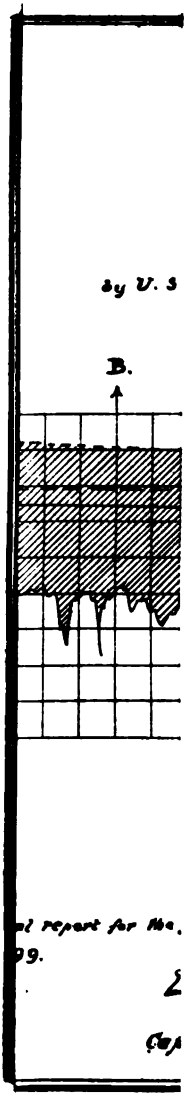

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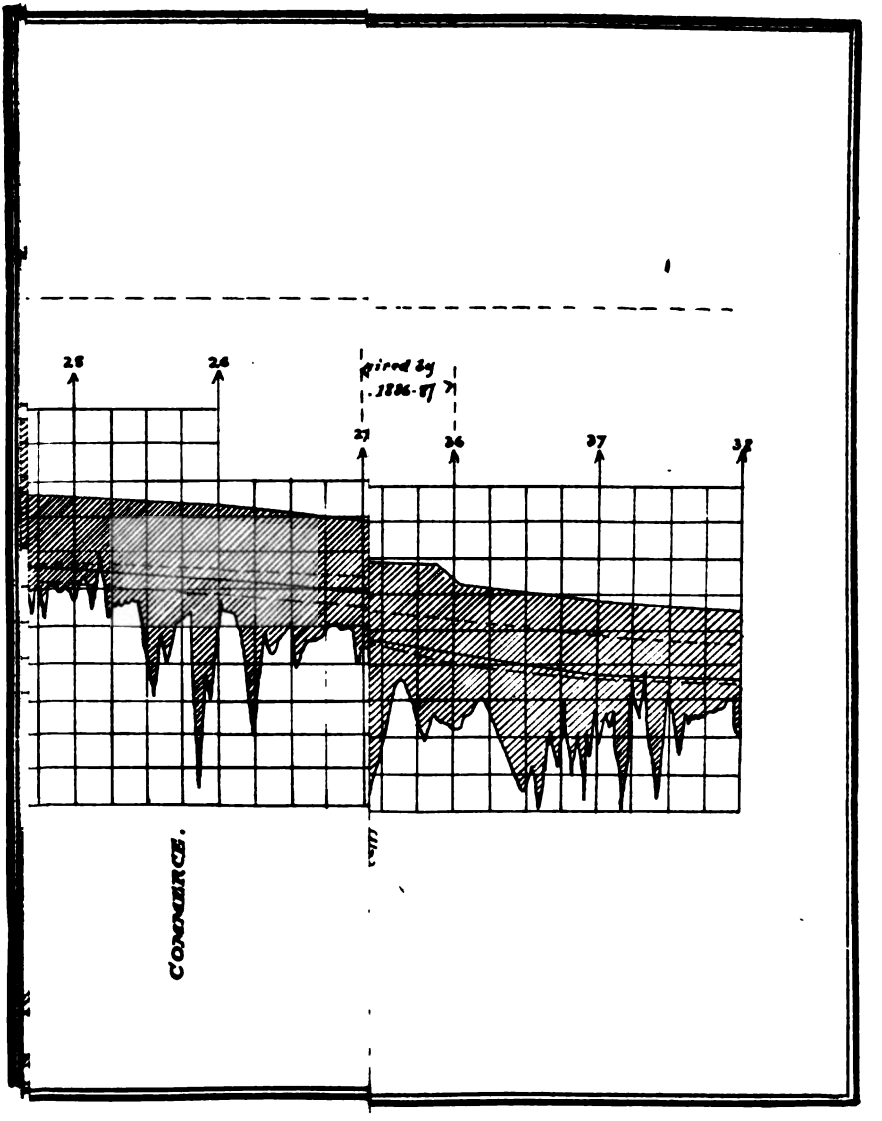

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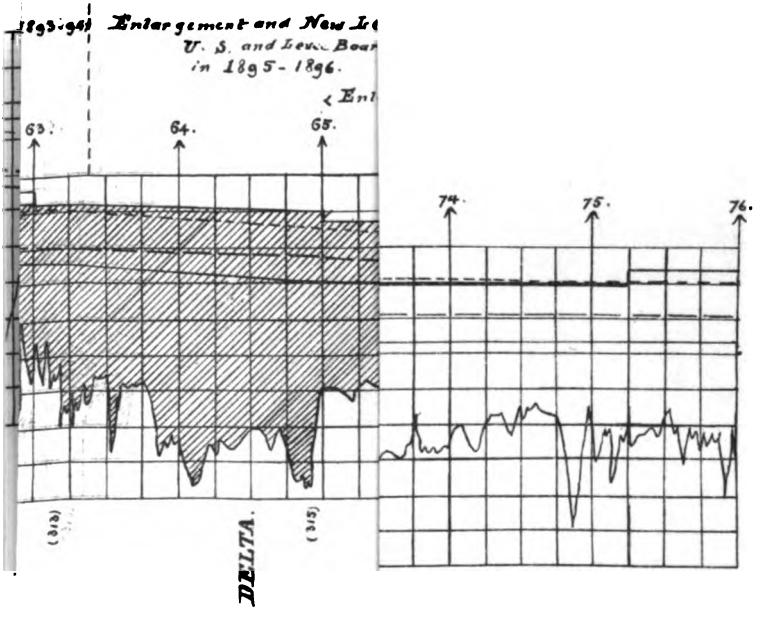

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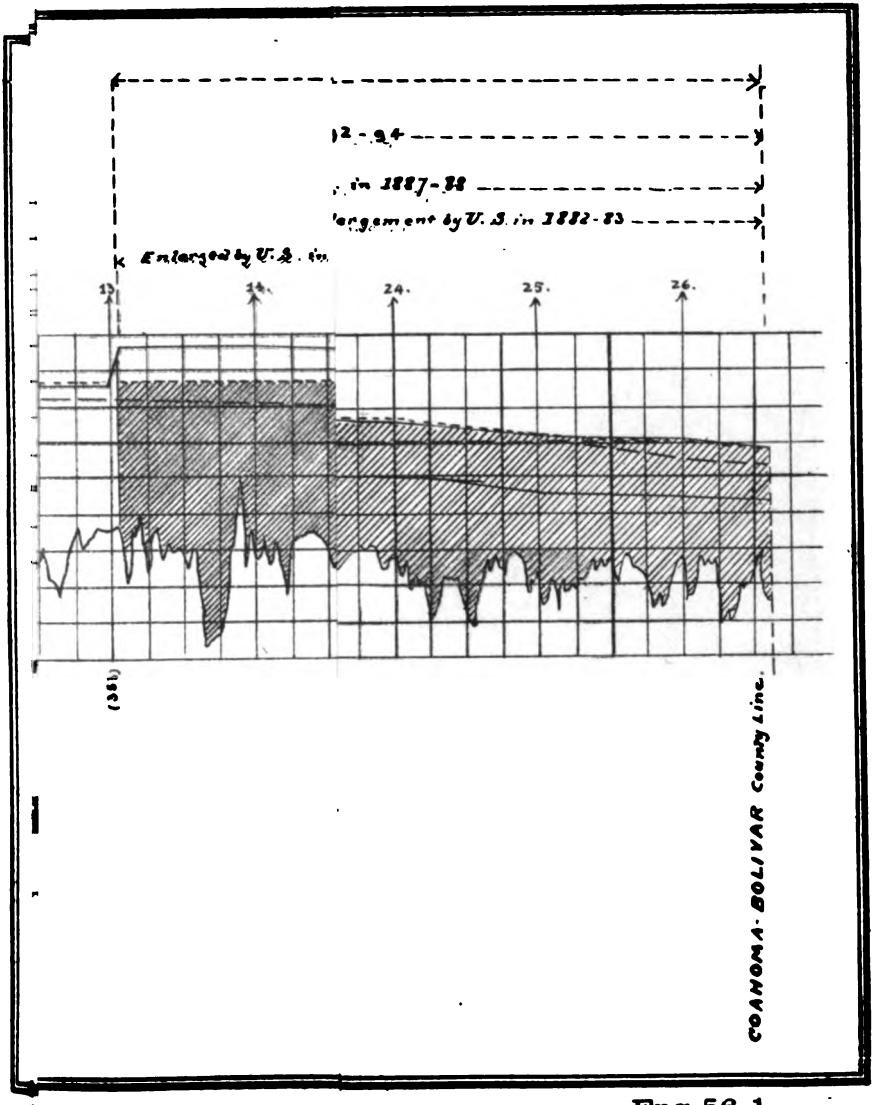

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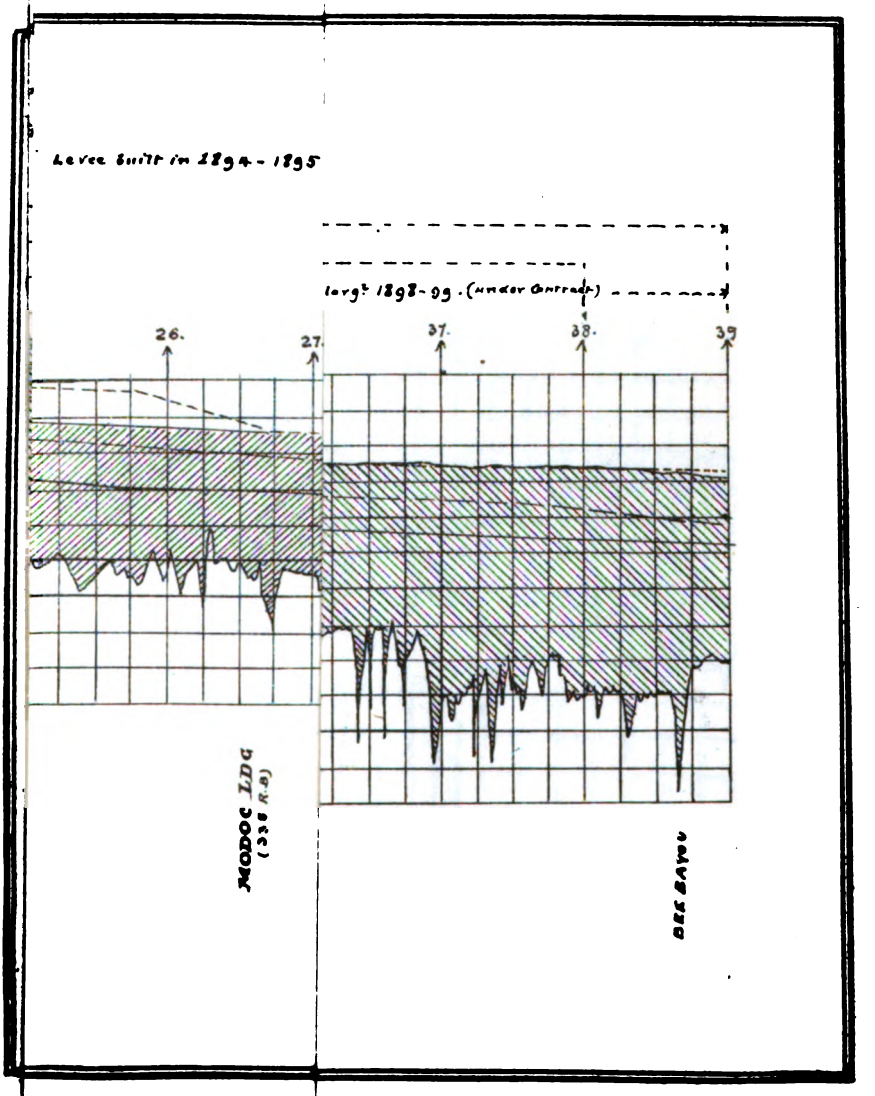

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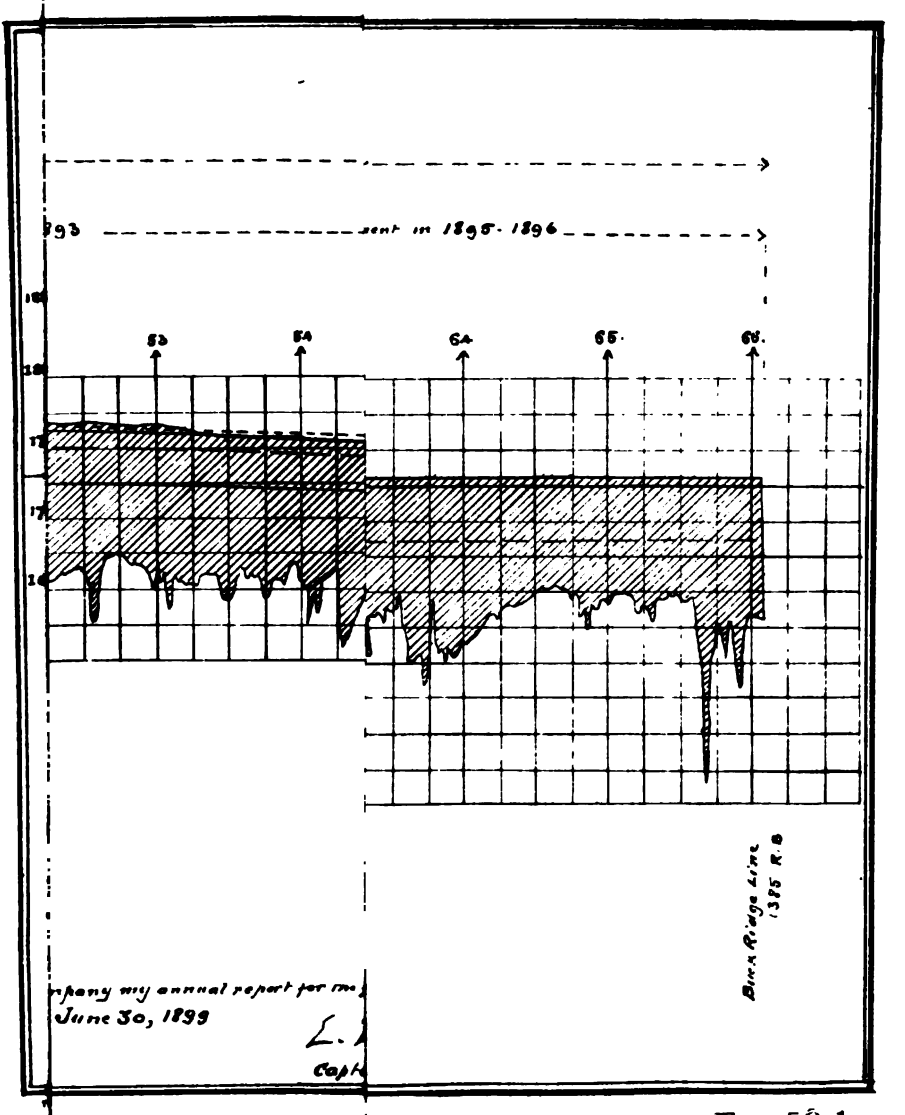

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List of civilian engineers employed on work of river and harbor improvement, first and second districts, improving Mississippi River, in charge of Capt. E. Eveleth Winslow, Corps of Engineers, from May 1, 1898, to April 30, 1899.

Name and address.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	Months.			
W. M. Rees, Memphis, Tenn.	12	$250	Memphis, Tenn.....	Principal office assistant; general superintendence of construction; plans for work at various localities.
Aug. J. Nolty, Memphis, Tenn.	12	175	Memphis, Tenn., and various points on Mississippi River.	Care and repair of plant; construction and repair of revetment at various points on Mississippi River; construction of experimental dikes near Point Pleasant, Mo.
Chas. LeVasseur, Memphis, Tenn.	11 1/6 1/6	150 165	Memphis, Tenn., and in the field.	Surveys and examinations; and draftsman computer in office.
A. F. Kilpatrick, Memphis, Tenn.	1/6 11 5/6	150 165	Askew, Ark..... Osceola, Ark., and Memphis, Tenn.	Construction and repair of levees in Lower St. Francis Levee district.
M. Gardner, Memphis, Tenn.	12	140	Sessions, Miss.....	Construction and repair of levees in Upper Yazoo Levee district.
C. H. Purvis, Helena, Ark.	12	140	Helena, Ark.....	Construction and repair of levees in White River Levee district.

APPENDIX 3.

REPORT OF CAPT. H. C. NEWCOMER, CORPS OF ENGINEERS, ON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 20, 1899.

COLONEL: I have the honor to submit the following report of operations in the Third district, improving Mississippi River, from May 1, 1898, to May 1, 1899.

The Third district extends from the Coahoma-Bolivar County line on the left bank (365 L.), and the mouth of the White River on the right bank (393 R), to the latitude of Warrenton, Miss. (607 L.). In its improvement works of bank protection have been executed at Lake Bolivar Front, Ashbrook Neck, Greenville Harbor, Lake Providence Reach, and Delta Point; the systematic improvement of Lake Providence Reach was attempted; and levees have been constructed and enlarged in the Upper Tensas and Lower Yazoo Levee districts. All of these localities are shown on the accompanying map of the Third district.

The operations of the past year have included repairs to the broken revetment at Ashbrook Neck, Greenville, and Lake Providence, the construction and maintenance of levees, towing stone, the construction of a towboat, and the care of plant.

LAKE BOLIVAR FRONT (417 MILES BELOW CAIRO).

The revetment at this place was built to hold a bank whose caving endangered a large levee across the head of Lake Bolivar. About 4,250 linear feet of revetment were constructed in 1888–89, and repairs were made in 1889, 1892, and 1893. Details of the work are given in the Annual Reports of 1889, page 2704; 1890, page 3252; 1893, page 3752; and 1894, page 2919, and maps accompany the reports of 1889 and 1890.

No work has been done since 1894. The revetment has been largely shielded from attack by a bar making downstream from the foot of Island No. 76. During the past season, however, this bar showed a tendency to cut away. With the exception of three small breaks in the upper bank paving, that first appeared after the flood of 1897 and have since remained practically unchanged, the revetment is apparently in good condition for a length of about 3,775 feet, measured along the shore edge of the mats. No extension is considered necessary. The total expenditures under this allotment have been $145,358.04.

ASHBROOK NECK (446 MILES BELOW CAIRO).

The revetment at this place was built to prevent a threatened cut-off, the minimum distance across the neck having been reduced to about 2,000 feet. About 2,820 linear

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feet of revetment were constructed in 1890–91, 4,300 feet in 1891–92, 2,610 feet in 1892–93, 1,475 feet in 1894–95, and repairs, principally to upper bank paving, were made in 1893–94 and 1897–98. A levee 7,300 feet long was built along the axis of the neck in 1891–92 to prevent flow across the neck, but it was destroyed in the next flood. Details of the work are given in the Annual Reports of 1891, page 3639; 1892, page 3170; 1893, page 3752; 1894, page 2920; 1895, page 3805, and 1898, page 3370. Maps accompany the reports of 1892 and 1893.

After the high water of 1898 two small breaks, similar to those of the previous year, appeared in this revetment, one between ranges 105 and 106, and the other at range 26. A project for repairing these breaks was submitted December 2, 1898, and approved. The high stage of the river, however, permitted only the construction of a pocket mat at the first break. This was built and sunk January 19–21, 1899, comprising 299 squares, at cost of $1,833.31, or $6.13 per square. Additional details are given in the appended report of Assistant Engineer Arthur Hider.

The Commission has allotted $20,000 to this work from the appropriation for the coming year. A project for the expenditure of this sum was submitted March 24, 1899, and has been approved by the Commission. It provides for the completion of the repairs to the above defects, and for a reserve supply of about 10,000 cubic yards of stone.

Disregarding the defects mentioned, the revetment appears to be in effective condition for a length of about 9,990 feet measured along the shore edge of mats. No extension is considered necessary, but new defects requiring repairs may appear after this year's flood. The total expenditures under this allotment have been $446,969.90.

GREENVILLE HARBOR (478 MILES BELOW CAIRO).

The revetment at this place (see accompanying map of Greenville Harbor) was built to protect the town of Greenville which was rapidly caving into the river when the work began in 1887. The first project was to hold the bank with submerged spur dikes consisting of cribs resting on foundation mats. In 1887, 1888, and 1889 twelve crib dikes were built, and one longitudinal pile dike, and mats were placed between some of the spur dikes. Caving continued, however, in the bend above, and during the flood of 1891 the upper dikes were flanked, four spur dikes and the longitudinal dike being carried away. The revetment of the bank above the remaining dikes was then begun, 6,600 linear feet being built in 1891–92, 4,450 feet in 1892–93, and 3,087 feet in 1894–95, woven mats being used in all this work. Repairs were made to upper bank paving in 1893 and 1894. In the flood of 1894 the upper remaining spur dike was carried away, leaving seven spur dikes still in position. Breaks in the revetment were repaired by the construction of about 677 linear feet of new revetment in 1896 using fascine mats, and 1,850 feet in 1897–98, together with considerable new upper bank work.

The details of the above operations are given in the Annual Report of 1888, page 2280; 1889, page 2706; 1890, page 3240; 1892 page, 3173; 1893, page 3753; 1894, page 2920; 1895, page 3805; 1897, page 3726, and 1898, page 3370. Maps accompany the reports of 1888, 1889, 1890, 1892, and 1893.

This revetment suffered severely during the high water of 1898. The bank was cut away behind the upper end of the work from about range 96 to about range 102. From range 108 to range 119 the revetment was practically destroyed; also from range 137 to 141, range 4 to 25, and range 43 to 47; giving a total of about 600 linear feet seriously damaged at the head of the work, and about 4,000 linear feet lost in the body of the work. I think the latter loss was due mainly to the failure of the subaqueous mats, which were of the woven type, built in 1891–92–93, aided somewhat, probably, by a cutting of the upper bank as in the flood of 1897. Minor defects also developed in the intervals between dikes 8½, 9½, 10½, and 11½, and there was some scour on the top of the bank between ranges 30 and 35.

A project for the expenditure of the $100,000 allotted to this work by Congress was submitted July 12, 1898. This provided for restoring the revetment as far as the funds would reach. Work was begun August 12 and completed March 8, 1899. Five channel mats were built with total length of 5,108 feet and area of 14,666 squares. Ten pocket mats were built, aggregating about 2842.7 squares, and about 5,882 squares of bank paving were laid. The 5,073 linear feet of new work cost about $25.28 per linear foot. Reference to the accompanying map of Greenville Harbor will show that the greater portion of this work has been renewed within the last three seasons.

It was also intended to put a mat in the pocket at the head of the work for its protection, but before this could be done the river reached such a high stage as to render it impracticable. Three small brush and stone dikes were then built on the top of the bank to check the cutting behind the revetment. The total cost of all repairs for the season was $137,161.04.

The work of the past season was much hindered by the quarantine restrictions

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existing from early in September until October 22, by the unusual amount of rainfall, the failure of the brush contractors to supply brush as rapidly as required, and largely also by the comparatively high stage of water throughout the working season. Additional details of the work are given in the appended report of Assistant Engineer Arthur Hider.

Congress having allotted $50,000 to this work from the Commission's appropriation for the coming year, a project for the expenditure of this sum was submitted March 24, 1899, and has been approved by the commission. This provides for protecting the head of the work by 300 linear feet of standard revetment, for a reserve supply of about 10,000 cubic yards of stone, and for repairs to plant amounting to about $25,000.

The length of revetment in effective condition is about 11,600 feet, measured along the shore edge of the mats. There are also about 2,900 feet of bank protected by the dikes.

The total expenditures under this allotment have been $799,271.24, not including $42,277.10 contributed by the town of Greenville in 1887.

LAKE PROVIDENCE REACH (517 TO 552 MILES BELOW CAIRO).

Earlier works.—This was one of the reaches first selected by the Mississippi River Commission for systematic treatment. The least low water depths on its crossings before its improvement was undertaken are variously reported as 4½ and 5 feet. The original project provided for giving the low-water channel an approximately uniform width of 3,000 feet, by constructing contraction works, closing all the chutes, and holding the caving banks. Instead of covering the entire reach of 35 miles, however, as originally intended, the works as built were confined to a reach of about 20 miles, from 522 to 542 miles below Cairo. Operations were begun in 1882 and actively prosecuted until 1885, and some repairs were made to these earlier works in 1886 and 1888-89. The Duncansby, Mayersville, Baleshed, and Stack Island systems of dikes were constructed on the Mississippi side of the channel, and the Cottonwood and Elton systems on the Louisiana side, and bank revetment was constructed at Louisiana Bend and Mayersville Island. The total lengths of the various constructions were about as follows: 112,396 feet of pile dikes, 48,238 feet of foot mats between dikes, 16,547 feet of foot mats along the dikes, 5,588 feet of screens in front of the dikes, 13,561 feet of wattling between dikes, 520 feet of shore revetment at the ends of dikes, and 33,476 feet of bank revetment. See Annual Report of 1895, page 3843, for a tabular summary of the work. The details of these works are given in the Annual Reports of 1883, page 2285; 1884, page 2814; and 1885, pages 2748 and 2960. Maps accompany the reports of 1883, 1884, 1888, and 1889.

These earlier works had a beneficial effect on the channel, but they were comparatively weak and were lost, partly through lack of funds for their maintenance and Congressional limitation of the use of bank revetment. The Duncansby system was reported as practically destroyed by 1886, the Louisiana Bend revetment by 1887, and by 1889 only portions of the system at Baleshed Bar and Stack Island remained out of all the works that had been built. Parts of these are still in existence, where not exposed to the destructive action of the river.

Louisiana Bend revetment (522 R.).—In 1889 active work was resumed. It was decided to revet the caving bank near the head of the reach in Louisiana Bend, hoping thus to give greater permanence to the channel throughout the reach. About 6,024 linear feet of revetment were built in 1889-90, 5,224 feet in 1891-92, and 5,835 feet in 1892-93, when further operations were suspended awaiting the results of the experiments with dredging. The type of revetment used was much stronger than that formerly employed, consisting of woven mats below water 260 to 345 feet wide and upper-bank paving of stone 10 inches thick. On account of the unstable nature of the bank along the mouth of Old River, it was necessary to make some repairs each year to the upper-bank paving, where sloughs occurred during low-water stages, and in 1892 and 1893 seven short spur dikes of brush and stone were built on the upper bank, where the high waters caused scouring behind the revetment. Breaks in the revetment were repaired in 1896-97 by the construction of about 1,247 linear feet of new revetment, using fascine mats. The details of these operations are given in the Annual Reports of 1890, page 3229; 1892, page 3177; 1893, page 3754; 1894, page 2921; 1895, page 3806; 1896, page 3653, and 1897, page 3727. Maps accompany the reports of 1890, 1892, 1893, and 1896.

After the flood of 1897 a number of breaks appeared between ranges 127 and 156. Thorough repairs would have required the practical renewal of this portion of the revetment. In view of the small amount of available funds, and the difficulty that had been experienced in holding this part of the bank, it was decided to abandon this part of the work for the present.

No work of construction has been done here during the year, and none is recommended. The length of revetment, including the above breaks, is about 15,820 feet, measured along the shore edge of mats.

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Lake Providence Revetment (540 R.).—This revetment was built to hold a rapidly caving bank that threatened to destroy the town of Lake Providence and the important levee across the foot of the lake. About 4,780 linear feet of revetment were built in 1894–95, 5,360 feet in 1895–96, and repairs to upper-bank paving were made in 1898. The details of the work are given in the Annual Reports of 1895, page 3806; 1896, page 3653, and 1898, page 3372. A map of the work accompanies the report of 1896.

The bank above this work caved considerably in 1898, thus exposing the head of the revetment to serious attack. In view of this condition the commission on December 9, 1898, allotted $10,000 for the protection of the work, directing that so much of this as was necessary be expended in strengthening the head of the revetment before the end of the season. A project was submitted December 17, and approved, providing for extending the revetment 300 feet upstream into the pocket formed by the caving bank, and carrying the fascine mat 100 feet downstream to strengthen the work in place. Work under this project was begun January 10, 1899, but had to be suspended January 26 on account of the high stage of the river. The water having fallen somewhat by February 26, work was then resumed. The river was still so high, however, as to present very unfavorable conditions for prosecuting the work, but this apparently was the last opportunity of the season, as another rise was coming. A mat 290 by 420 feet was accordingly built. In sinking it the head cables broke, allowing the mat to swing somewhat out of its desired position. A pocket mat of 191.7 squares was then built to connect it with the shore. No bank paving could be done on account of the stage of the river. For the same reason the work of hydraulic grading was wholly lost. The cost of the repairs amounted to $10,910.37. Additional details are given in the appended report of Asst. Engineer Arthur Hider.

The commission, on March 9, 1899, allotted $25,000 to this work from the appropriation for the coming year. A project was submitted March 24 providing for further strengthening the head of the work by the construction of 300 linear feet of standard revetment, and for a reserve supply of about 10,000 cubic yards of stone for future repairs. The commission, however, decided that the revetment should be extended upstream as far as practicable with available funds for the protection of a portion of the levees threatened by the caving bank—levees that I had proposed to replace in the usual manner by a new line in a more retired position—and an additional allotment of $35,000 was made for this purpose. The total allotment of $60,000 will provide for an upstream extension of about 2,000 feet.

The length of this revetment in good condition is estimated at about 9,800 feet.

The following table gives the least depths reported on crossings in Lake Providence Reach for the different years:

Date.	Crossing.	Depth on crossing.	Reading of Lake Providence gauge.
		Feet.	*Feet.*
1879	Stack Island	5	0.55
1884, Aug. 30	do	10	8.9
1885, Oct. 20	Ben Lomond	13	7.1
1886, Sept. 30	Stack Island	8.5	4.7
1887, Sept. 10	do	7	4.5
1888, Oct. 23	do	9	5.75
1889, Nov. 1	Ajax Bar	7	2.25
1890		11	8.5
1891		7	10
1892, Oct. 23	Ajax Bar	5.5	1
1896, Oct. 30	Wilsons Point	12	1.6
1897, Oct. 11	do	7	—2.2
1898, Oct. 31	do	9	7.8

Extreme low-water depths of 6 to 7 feet have been reported for the years 1893–95.

A channel 15 feet deep was dredged through Wilsons Point Crossing in October by the dredge *Gamma*.

The total expenditures for the reach have been $3,547,540.47.

DELTA POINT (598 MILES BELOW CAIRO).

The cut-off that occurred at Vicksburg in 1876, and the subsequent shoaling of the channel leading from the river to the resulting lake front of the city, practically destroyed the harbor of Vicksburg for low-water commerce.

The first operations undertaken for the improvement of the harbor consisted in revetting the rapidly caving bank at Delta Point, as its continued recession was

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increasing the distance from the harbor proper to the channel of the river. From 1878 to 1881, before the Mississippi River Commission assumed charge of the work, there were built about 5,400 linear feet of revetment, one mattress spur dike, and two screen dikes, at a total cost of $203,229.87. The details of the work for this earlier period are found in the Annual Reports of 1878, page 637; 1879, page 974; 1880, page 1333; 1881, page 1384, and 1882, page 1502.

The river and harbor act of August 2, 1882, placed this work under the supervision of the Mississippi River Commission. The work of revetment at Delta Point was continued, 1,100 linear feet of revetment being built in the season of 1882–83, 2,200 feet in 1883–84, 2,083 feet in 1884–85, 1,065 feet in 1893–94, and repairs to upper-bank paving were made in 1898. Practically all the work prior to 1882 is destroyed or covered by the later work. Only the mats of 1893–94 have the present standard width of 300 feet, the earlier ones being from 150 to 175 feet wide. Details of the work under the Commission are given in the Annual Reports of 1883, page 2290; 1884, page 2820; 1885, pages 2787 and 2964; 1889, page 2709; 1893, page 3754; 1894, page 2921, and 1898, page 3373. Maps accompany the reports of 1883, 1884, 1888, 1889, and 1893.

After the flood of 1897 it became apparent that the work of 1893–94 should be extended into the pocket formed by caving above and below it in order to hold the salient position occupied by this work. The commission allotted $40,000 for this purpose June 18, 1898. A project was submitted July 12, 1898, and approved, providing for an extension of about 900 feet upstream, and about 800 feet downstream. The season was so unfavorable, however, for revetment operations that the necessary work at other points could not be completed in time to permit this project to be executed by the single revetment party that could be organized with the available plant. It is intended to do this work during the coming season.

Much of the revetment at the lower end of the work is covered up by deposit, so that practically the only work remaining that is now exposed to attack is that of 1893, of which apparently about 900 linear feet are in effective condition.

The improvement of Vicksburg Harbor proper is now in charge of the Engineer Department, in accordance with the project adopted by the river and harbor act of July 13, 1892, providing for the diversion of the Yazoo River into Centennial Lake. A summary of the work done in the harbor by the Mississippi River Commission is given in the Annual Report of 1897, page 3728.

The expenditures here under the Mississippi River Commission have been about $442,724.77 in Vicksburg Harbor and about $145,593.70 at Delta Point, thus giving total expenditures at Delta Point of about $348,823.57.

LOWER YAZOO LEVEE DISTRICT (365 TO 592 MILES BELOW CAIRO).

This district extends in Mississippi from the Coahoma-Bolivar County line to the mouth of the Yazoo River, being practically coterminous with the local Mississippi levee district.

The levee line is continuous from the upper end of the district to Kigers, on Eagle Lake. Its length, after completion of loops now under construction, will be about 188.6 miles, covering about 220 miles of the river.

During the past year there have been added to the line by the United States about 2,845,342 cubic yards, and by the local board about 670,961 cubic yards. It should be noted that over one-third of the expenditures by the local board have been for rights of way and damages to property affected by levee work. The length of line thrown out by the construction of new loops, including those now under construction, will be about 120,557 feet, containing about 2,575,891 cubic yards, thus giving net contents of the line May 1, 1899, of about 26,601,026 cubic yards. The United States have built altogether about 13,949,268 cubic yards. Tabular statements of expenditures and work done by the United States accompany this report.

It is estimated that about 3,759,000 cubic yards of earthwork will be required after the completion of existing contracts to bring the levees in this district to the provisional grade of 3 feet above the high water of 1897, or about 19,024,000 cubic yards for the ultimate grade adopted by the commission, which averages about 5.4 feet above the high water of 1897.

The commission having allotted a considerable portion of the levee funds for the year in February, 1898, work was advertised under these allotments and bids received as soon after the flood of 1898 as the conditions became favorable for levee operations. About 197,000 cubic yards of banquet work were let May 14, 1898, at average price of 9.32 cents per cubic yard. The principal letting of the season was on July 6, when bids were received for about 1,610,000 cubic yards, the average price being 12.54 cents. On August 12 about 501,000 cubic yards more were let, at an average price of 14.46 cents. On January 16, 1899, a small loop at Baleshed, Miss. (537 L), was let at 15.7 cents per cubic yard. This gave a total of about 2,333,000 cubic yards let during the year at average price of 12.7 cents per cubic yard, under allotments

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aggregating $357,000. Including the 24 contracts remaining unfinished at the date of my last annual report there were 59 pieces of work under agreement for construction during the year. Twenty-two of these remain incomplete and 2 have been abandoned. The incomplete contracts include about 2,239,294 cubic yards, of which about 869,690 cubic yards remain to be placed. Although the original agreements provided for the completion of all this work by February 1, 1899, I consider the results obtained as quite satisfactory in view of the extremely unfavorable character of the season. While yellow fever quarantine restrictions caused some trouble in September and October, the principal difficulty was on account of the excessive rainfall during the months of August, September, October, and November. The rainfall at Greenville during these four months was 24.41 inches as compared with a mean of 11.91 inches for the same months in the preceding twelve years.

The flood of 1899 was not of sufficient magnitude to require much work for the high-water protection of the levees. The wave wash was very heavy on the new earthwork at some places, and the local authorities took steps to check this action where it threatened to impair the security of the line. The principal high-water work undertaken by the Government was the construction of a protection loop at Shiloh (555 L.) while the flood was at its highest stage. Active caving began here after the water was well over the bank, and made it necessary to build a loop about 1,800 feet long, containing about 18,000 cubic yards. The small loop built at Baleshed (537 L.) in February and March may also be considered a piece of emergency work, as it was intended mainly to give protection during this year's flood. The two large loops under construction at Hays (554 L.) and Ingomar (568 L.) by the United States and the levee board, respectively, were not finished, and protection loops had to be built at both these points. About 450 square miles of land were inundated by backwater at the lower end of the Yazoo Basin.

The Stop Landing Levee (434 L.), that gave so much trouble by its great sinking last year, was built up to grade in December, 1898, and has settled very little since then.

Some work has been done during the year in repairing slopes that were wave washed and gullied by rains, and in cutting weeds to secure a better growth of Bermuda sod.

The commission having allotted $247,000 for this district for the coming year, a project covering the expenditure of this sum was submitted March 30, 1899, and has been approved by the commission. This provides mainly for continuing the enlargement to 3-foot grade southward from Station 2108 (514 L.), reserving sufficient money to top up the lower end of the line that can not be regularly enlarged.

Additional details of the year's work are given in the appended report of Mr. H. St. L. Coppée, assistant engineer, in local charge of the district.

The total expenditures by the United States for levees in the Lower Yazoo district have been $2,434,264.03.

UPPER TENSAS LEVEE DISTRICT (402 TO 606 MILES BELOW CAIRO).

This district extends from the Arkansas River to a point in Louisiana opposite Warrenton, Miss. There is a continuous levee line about 171.66 miles long, extending from Costello's gin, on Amos Bayou, along that bayou and Cypress Creek to the Mississippi River (13 miles), and thence along the river to the lower end of the district (158.66 miles).

The district is protected from overflow of the Arkansas River by a levee line along that river from the vicinity of Pine Bluff to the foot of Lake Jefferson. From Pine Bluff to Red Fork this line is of comparatively weak section, built and hitherto maintained by the local authorities. From Red Fork to the foot of Lake Jefferson (12.4 miles) the line was built in 1894–96 by the United States with the standard section of 8-foot crown and slopes of 1 on 3.

During the past year there have been added to the line by the United States about 1,479,539 cubic yards, and by the local authorities about 617,082 cubic yards. The length of line thrown out by the construction of new loops was 31,305 feet, containing about 1,083,694 cubic yards, thus giving total contents of levees May 1, 1899, about 24,724,455 cubic yards. The United States have built altogether about 18,279,736 cubic yards. Tabular statements of expenditures and work done by the United States accompany this report.

It is estimated that it will require, after the completion of existing contracts, about 4,403,172 cubic yards to bring the levees in this district to the provisional grade of 3 feet above the high water of 1897, or about 18,542,896 cubic yards for the ultimate grade adopted by the commission, which averages about 5.5 feet above the high water of 1897. To close the gap between Lake Jefferson and Cypress Creek at the head of the system will increase this estimate to a total for the commission grade of about 21,000,000 cubic yards.

About 1,503,000 cubic yards of work have been let in this district during the year

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at average price of 14.34 cents per cubic yard, under allotments aggregating $215,000. Including the 21 contracts remaining unfinished May 1, 1898, there were 51 pieces of work under agreement for construction during the year. Of this number 28 remain incomplete, covering about 1,926,472 cubic yards, of which about 765,051 cubic yards are still to be done.

There were no high water operations of any moment in this district. There was practically no land south of Amos Bayou (405 R.) inundated by the water (estimated at 2,400 cubic feet per second) passing around the head of the system. North of Amos Bayou, however, the backwater covered an area of about 72.5 square miles that will probably be protected from overflow when the levee system is complete.

The commission having allotted $197,600 to this district for the coming year, a project for the expenditure of this sum was submitted March 30, 1899, but did not receive the approval of the commission, on account of the short line proposed just above Lake Providence (542 R.). This short line would replace a long line of levee, portions of which are now threatened by caving banks. It would throw out about 20 square miles of land, but would shorten the line about 12 miles. These 12 miles have already cost about twice as much as the value of the land that they are maintained to protect, and it is estimated that their future maintenance will cost more than the value of the land again as compared with the cost of the proposed short line. There is no way, however, by which the landowners could be reimbursed for their losses if thrown out. The commission has directed that a new project be submitted at its next meeting providing for the maintenance of the front line.

Additional details of the year's work are given in the appended report of Mr. E. C. Tollinger, the assistant engineer in local charge of the district.

The total expenditures by the United States for levees in the Upper Tensas district have been $3,633,628.52.

SURVEYS, GAUGES, AND OBSERVATIONS.

Surveys were made of Carters Neck and Caulks Neck to determine the rate of caving, and complete surveys were made of the different revetments throughout the district in July and August, 1898. About 47.8 miles of bank line were also run in the following bends: Cypress (425), Choctaw (435), Rowdy (450), Spanish Moss (467), Walkers (488), Matthews (502), and bend of Island 92 (528). The results of these surveys were plotted and maps made. Additional details are given in the appended report of Assistant Engineer Arthur Hider. The total expenditures under this allotment have been $72,929.32.

STONE.

Under their contract to deliver 30,000 cubic yards of stone on Government barges at Bee Rock Quarry in Little Red River, at 47.9 cents per cubic yard, Edmond Ligon & Co. had furnished 11,743 cubic yards by May 1, 1898. They delivered 11,112 cubic yards more between May 1 and June 10, when further operations were prevented by the low stage of water in the Little Red River. The total amount delivered under the contract was 22,855 cubic yards. The cost of towing this stone to Greenville was 86.8 cents per cubic yard, including the cost of repairs to the plant used in towing. Omitting the repairs the cost of towing was 80.4 cents per cubic yard, or about 2.7 mills per yard-mile. The cost of unloading the stone on the bank at Greenville was only about 12.23 cents per cubic yard, on account of the high stage of the river. The cost of the stone delivered on the bank was therefore about $1.47 per cubic yard.

The cost of towing was considerably increased by the failure of the contractors to load the barges as rapidly as they could be received. The aggregate number of days the towboats were in commission was 239. Of this number 55 were lost by the boats while waiting for tows at the quarry. It was thought that the quarry could be operated more satisfactorily if owned by the Government, and it was therefore purchased for $2,000. This quarry, known as Bee Rock Quarry, is situated on the right bank of the Little Red River, about 33 miles above its mouth and about 210 miles from the mouth of White River. The property comprising the quarry has a river frontage of about 2,640 feet, and is described in the deed as "the following lands lying in the county of White and State of Arkansas, to wit:

"The fractional west half of the southeast quarter (located on the right bank of the river) of section twenty-six (26), in township eight (8) north, range seven (7) west, containing 26.8 acres, more or less."

About 800 feet of the river front have been opened up in the development of the quarry, with an average height of quarry face of about 100 feet. The stone varies gradually from a light-colored sandstone at the top to a dark, heavy quartzite in the lower strata, mostly of excellent quality, but with some thin seams of poor material, like shale. The strata are from 4 to 10 inches thick. This laminated structure makes the stone especially suitable for paving banks in revetment work.

The total expenditures under this allotment have been $189,722.76.

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PLANT.

Repairs to plant were made during the year as shown in the detailed statement accompanying the report of Mr. Hider. The cost of repairs amounted to $13,462.77, and the cost of caring for the floating plant and other property amounted to $20,486.24.

The new steel-hull towboat *Arthur Hider*, that was under construction May 1, 1898, at Jeffersonville, Ind., by Mr. Ed. J. Howard, was completed and delivered at Greenville in December. Her performance has been very satisfactory. It is proposed to build 12 barges and 2 mat boats during the coming season, so as to provide sufficient plant for the organization of two revetment parties. The total expenditures under this allotment have been $683,398.17.

The following papers and maps accompany this report:
Report of Mr. Hider on surveys, revetment work, stone, and plant.
Report of Mr. Coppée on levees in Lower Yazoo district.
Report of Mr. Tollinger on levees in Upper Tensas district.
Tables showing cost of work done by the United States on levees.
Map of Third district.
Map of Greenville Harbor.
Financial statements.
Abstract of proposals.
List of civilian engineers.
Statement of contracts in force.

Very respectfully, your obedient servant,

H. C. NEWCOMER,
Captain, Corps of Engineers.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

REPORT OF MR. ARTHUR HIDER, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 8, 1899.*

SIR: I have the honor to submit the following report of surveys, construction work, repairs to plant and care of same from May 1, 1898, to April 30, 1899:

SURVEYS.

A survey party was organized under the immediate charge of Mr. C. H. Miller, surveyor, July 11, to make a survey over the different revetments and determine changes in bank lines.

The party consisted of chief, four assistants, a steamboat and crew, and six laborers.

The field work was done during the hottest part of the season, and the party suffered a good deal from sickness.

The field work was finished August 20 and the office work September 20.

The expense of the survey was—

For salaries and wages (including crew of steamboat)	$1,920.87
Subsistence	276.03
Material and supplies	90.79
Total	2,287.69

The field work consisted of soundings over the following revetments: Bolivar Front, Ashbrook Neck, Greenville Harbor, Louisiana Bend, Lake Providence, and Delta Point; the determination of changes in the bank line on the upper side of Caulks and Carters Neck, and the location of bank line in the following caving bends: Cypress, Choctaw, Rowdy, Spanish Moss, Walker, Mathews, and the bend of Island 92.

Forty-seven and eight-tenths miles of bank line were located for this purpose.

The office work consisted of reducing notes and plotting these surveys. The following maps were prepared:

One index map and 4 sheets of sections, Bolivar Front.
One index map and 5 sheets of sections, Ashbrook Neck.
One index map and 12 sheets of sections, Greenville Harbor.
One index map and 6 sheets of sections, Louisiana Bend.
One index map and 5 sheets of sections, Lake Providence.
One index map and 4 sheets of sections, Delta Point.
One map, Caulks Neck.
One map, Carters Neck.

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Total, 8 maps and 36 sheets of sections. In addition the changes in shore lines in the caving bends were plotted on charts and tracings, scale 1:20,000.

The condition of the different revetments, as shown by these surveys at the time, was as follows:

Bolivar Front revetment.—A general fill is indicated over the revetment from the upper end as far down as range 23+08. From this it does not appear that any additional work will be required for the present, as the main current of the river is now and has been for some years on the opposite side. As long as these conditions continue there is little likelihood of damage. No work has been done the past season on this revetment.

Ashbrook Neck revetment.—This work stood through the high water without being damaged to any great extent. Two slips occurred in the upper slope after the river was within its bank, one between range 105 and range 106 and the other at range 26. Similar defects appeared after the high water of the previous season at three different places, and were repaired during the previous low water. In order to hold this work permanently it is recommended that a line of channel mats of standard construction be sunk along the front of the revetment its entire length. It is probable that slips like those that have taken place after the last two high waters will occur at other points. These are expensive to repair and are at best but patchwork. This revetment was constructed in 1888–89, and is in an important position, being on the upper side of the narrowest neck on the river, for the protection of which it was built.

The fault between range 105 and range 106 was partly repaired. On account of the high stage of water and the lateness of the season it was impracticable to repair break at range 26 without neglecting more important work, and as the defect appeared to be comparatively slight the repairs were deferred to next season.

Greenville Harbor revetment.—This revetment suffered serious damage from the high water. The soundings showed that at the upper end of the revetment from range 96 to range 102 the bank had been washed out behind the revetment. Apparently the damage was primarily due to the caving back of the bank above, allowing the exposed part of the upper bank to be attacked by the strong current. From range 102 to range 109 the revetment apparently had not been injured materially. At range 109 the top of the upper bank slope had been scoured off. From range 110 to range 113 the subaqueous mattress was broken up. Between range 117 and range 118 there had been considerable scour under the mattress. From range 108 to 115 the upper slope had been destroyed, and from range 116 to range 119, leaving the upper slope between range 115 and range 116 intact. Between range 137 and range 140+50, just above the pocket mat put in to repair the revetment last season, a slip occurred after the survey was made. Between range 4 and range 25 the upper bank had caved back to such a distance as to require new revetment. Between range 43 and range 47, just below the work repaired the previous season, the upper bank slope had been destroyed, indicating that the subaqueous mat originally constructed in 1891–92 had been injured to such an extent as to require renewal. A scour had occurred on top of the bank between range 30 and range 35. This hole was about 500 feet long, 60 feet wide, and 3 feet deep.

Later in the season, as there were indications of the slipping of the upper bank between dikes 8¼ and 9¼, dikes 9¼ and 10¼, and dikes 10¼ and 11¼, shore mats were sunk in each of these pockets to reenforce the original work. All defects from range 108 to the lower end of the continuous revetment, range 70, were repaired, and brush hurdles built on the top of the bank near the head of the work to counteract the effects of scour, which had already begun.

Louisiana Bend revetment.—From the head of the original work to range 98 there has been an extensive fill. From range 98 to range 129 little change is indicated, except at range 122, where a heavy scour is shown. From range 134 to range 158 heavy scour is indicated, and the original mattress has probably been destroyed. From range 158 to range 162 the mat constructed in December, 1896, seems to be still intact. Below this the bend is caving rapidly. The bar line on the opposite side has made out toward the caving bank. To hold the bend will require practically a renewal of the lower part of this revetment. No repair work was done the present season.

Lake Providence Revetment.—At this point the river is still very wide, except at the upper end of the revetment, with a rapidly caving bank above, which threatens the stability of the work. The survey shows that from range 0 to range 12 a heavy fill has taken place; from range 12 to range 78 there has been but slight change; above range 78 to range 137, the upper end of the work, a deep scour is shown along the outer edge of the mattress. At the time the survey was made the caving from above had already extended down to the head of the work. This caving continued to increase as the river fell, and attacked the head of the work which was exposed, destroying about 200 feet of the upper bank slope. Late in the season a mattress was sunk to protect the revetment from further injury, as the stage of water

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and the limited time would not admit of repairs being completed in accordance with the original project.

In order to prevent further injury additional work will be required the present season.

Delta Point Revetment.—There has been extensive sloughing of the upper bank between range 25 and range 35, but with little change from the conditions existing last season below the zero line. The sections from range 6 down to the lower end indicate that they have filled to about their original depth, the scour shown by the survey of 1897 having been replaced by deposit. At range 0 little change has taken place. Since the survey the upper bank has caved back, due to undercutting, caused by eddy action in the pocket above the incline. This has endangered the tracks of the Vicksburg, Shreveport and Pacific Railroad. A considerable amount of work will be necessary at this point the coming season to keep the present bank line intact.

On account of having but one outfit, the large amount of work projected, the unfavorable season, delays from quarantine restrictions, and other causes, it was impossible to finish the repairs laid out at other points and make the repairs as projected for this point. Hence no work was done here.

Caulks Neck.—The caving on the upper side of the neck, since the survey of last year, shows a maximum bank recession of 250 feet, which is a short distance below the narrowest part. The average depth of caving was 115 feet. Very little change was observed in the surface conditions across the neck itself.

Carters Neck.—The average depth of caving along the upper part of this neck since the last survey was about 60 feet, with a maximum of 130 feet. The greater part of the caving is above the narrowest part of the neck. No noticeable change was observed in the condition of the water holes and washouts previously scoured out across the neck.

REPAIRS TO REVETMENT.—GREENVILLE HARBOR (478 L.).

The project as modified was for the construction of standard fascine mats 300 feet wide, from range 109 to range 119; from range 4 to range 25, and from range 42 to range 50, where the original mattresses had been injured or destroyed, and the grading and paving with riprap of the upper bank slopes; to construct pocket mats between dikes 8½ and 9½, 9½ and 10½, and 10½ and 11½; to protect the upper end of the revetment with brush hurdles on top of the bank, and to raise the slope paving from range 119 to range 137, to the 34-foot stage; the remaining funds to be used in the construction of a line of mattresses 250 feet wide, between range 4 and range 119, to strengthen the original work.

Work was begun August 12 with hydraulic grader and a small force stripping the stone from the injured slope in advance of the grader. The first brush was received on the 20th, and construction of head of mat begun on 21st; wire cable was received on the 26th, and mat building begun on the 27th; mat construction was finished January 16, 1899, and the mat party moved to Ashbrook Neck, leaving the upper bank paving to be finished as the water rose. The entire work of repairs was completed March 8, 1899, just in advance of the rising water.

Mattress construction.—The dimensions of mats constructed were as follows:

	Squares.
Mat No. 1, 800 by 300 feet	2,400
Mat No. 2, 965 by 300 feet	2,895
Mat No. 3, 960 by 300 feet	2,880
Mat No. 4, 1,067 by 300 feet	3,201
Mat No. 5, 1,316 by 250 feet	3,290
Total linear feet, 5,108.	
Pocket mat No. 1, main work	177.7
Pocket mat No. 2, main work	242.5
Pocket mat No. 3, main work	409
Pocket mat No. 4, main work	122
Pocket mat No. 5, main work	104.5
Pocket mat No. 6, main work	258
Pocket mat No. 7, main work	108
Pocket mat No. 1, between dikes	424
Pocket mat No. 2, between dikes	511
Pocket mat No. 3, between dikes	486
Total	17,508.7

Mat No. 1 was sunk between range 42 and range 50, filling the gap left between the fascine mats of 1896–97; mats 2 and 3 covered the space between range 4 and range 25; mat 4 was sunk in front of the break between range 109 and range 119;

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mat 5 (250 feet wide) covered the space from range 137 to range 4, lapping mat 3. The fascine mats on this work are now continuous from range 137 to range 57, except between range 119 and range 137, a distance of 1,800 feet. A mat could have been built here also but for the failure of the contractors to furnish brush as rapidly as required. In view of the lateness of the season, however, the uncertainty of a sufficient supply of brush, and the probability of an early rise in the river it was decided to build the three pocket mats between the dikes, and utilize the rest of the season in making repairs to the Ashbrook Neck and Lake Providence revetments, as the upper bank revetment in front of the gap of 1,800 feet was intact, and the repairs to the other revetments were considered of greater importance. Seven shore or pocket mats were constructed to connect the main mattress with the shore where the bank was irregular, and three sunk between the dikes in front of Greenville.

Grading.—Grader No. 1 was in service from August 12 to January 3, 1899. On September 12 an extra night crew was put on so as to keep well ahead of the mat building, but the bank caved so badly that it was found advisable to wait until after the mat was sunk before grading this part of the bank, and the night crew was withdrawn on September 24, the rest of the grading being done with a single crew working eight hours per day. The average rate of progress was 50 linear feet per day. Average cost per linear foot, 87.7 cents, which includes grading down about 600 feet of levee, with an average height of about 14 feet. Including the expense of regrading 1,000 feet of bank the cost per linear foot would be $1.01. To the usual difficulties of grading a sandy bank was added the drawback of a comparatively high stage of water during the greater part of the season, necessitating considerable regrading.

The work of filling holes left by grader and trimming slope was done with teams and shovels, costing 37 cents per linear foot, making the total cost per linear foot of graded bank $1.38.

Bank paving.—The thickness of the riprap varied from 6 inches in pockets where not exposed to the direct action of the current to 10 inches on points and exposed parts of the slope. About 5,882 squares of paving were laid at a cost of $5.93 per square.

Minor repairs.—These consisted of filling in the scour on the top of the bank, stations 30 to 35; the construction of 300 feet of hurdle dike near the head of the original revetment, and the raising of the slope paving along the old work from the 28 to the 34 foot stage, or to the top of the bank where below this height.

ASHBROOK NECK REVETMENT (446 L.).

The original project contemplated the repairs of the defect between range 102 and range 106, and that in the vicinity of range 26, by constructing a pocket mat at each place and regrading and repaving the slope where broken down. The high stage of the river (38 feet on the Arkansas City gauge) precluded any satisfactory work being done at the time the party arrived, as it was impracticable to grade the banks. The defect at range 26 which was near the foot of the slope was submerged 20 feet under water.

The outfit arrived on January 19, 1899, and began the construction of a pocket mat to cover the defect between range 102 and range 106. This mat was sunk in place on the twenty-first, being held by cables to the bank, so as to shield the upper bank immediately behind the mat. Nothing was done at range 26, on account of the unfavorable conditions preventing any satisfactory repairs being made, except at a very great expense. As this defect was not considered serious, it was deemed advisable to defer repairs until next season, as it was important to make the repairs at Providence before the river rose out of its banks.

The repairs done consisted of 299 squares of pocket mat which cost $1,833.31, or $6.13 per square. The stone for these repairs was obtained from the reserve on the bank.

LAKE PROVIDENCE REVETMENT (540 R.).

The original project for the repairs to the head of the revetment was to extend the revetment 300 feet upstream, and into the pocket formed by the caving at its head, carrying the fascine mattress downstream 100 feet, over the work then in place. Active caving continued above and into the pocket and had attacked and destroyed about 200 feet of the upper slope when mat building began.

The entire bank to be covered by the mat was graded between January 10 and 17, 1899, but the rapid rise in the river caused the bank to cave and destroy the work done. The working plant arrived on the 24th from Ashbrook Neck, and the head of the mat was constructed. Work was suspended on the 26th and the force disbanded, awaiting a fall in the river, when work could be accomplished with less risk. On February 26 work was again resumed and the mattress completed ready for sinking on March 7. This mat was 420 feet long and 290 feet feet wide, and was unusually strong in construction, as it was expected that great difficulty would be experienced

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in sinking, owing to the fact that the mat lay partially in an eddy, with an upstream velocity of 4 feet per second, while a strong downstream current swept across the outer edge at an angle of about 37 degrees.

In sinking the mat, due to the excessive and unequal strains developed, the steel cables holding the mat parted one by one, beginning on the outside, allowing the mat to pivot on the point below and swing down and out, moving downstream about 175 feet, where it was sunk. A small pocket mat was built connecting this mat with the shore.

This work will afford partial protection to the head of the revetment, but additional work will be required the next season to insure permanency, either by continuing the work a considerable distance upstream, or additional mats immediately above the present head of the work. The cost of these repairs was $10,910.37.

GENERAL REMARKS ON REVETMENT WORK.

Towing.—The principal towing of brush and stone was done by the steamer *Emma Etheridge*. The tug *Parker* was used for harbor work at Greenville, and the steamer *Arthur Hider* at Lake Providence.

Stone.—This was partly supplied from the reserve on the banks, and was also received by rail at Greenville under contract with A. J. Terrell, whose first contract was for about 10,000 cubic yards loaded on barges at Greenville at $1.46 per cubic yard. Under this contract 9,973.08 cubic yards were received. Later in the season a second contract was made with the same party for 3,000 cubic yards, more or less, delivered on the bank at Greenville, at $1.42 per cubic yard. Under this contract 3,544.45 cubic yards were received. The stone from the reserve was loaded on barges under contract with A. J. Terrell at 23.6 cents per cubic yard. About 19,776.62 cubic yards were loaded under this contract. This stone was used in the repairs at Greenville and Lake Providence.

The stone from the Little Red River quarries is much more suitable for riprap and for sinking mattresses, both on account of greater specific gravity and also from the fact that it can be readily quarried to dimensions most suitable for the requirements of the work.

Brush and poles.—These were furnished under contract with Hunter & Frey. The contract price for the brush was 87 cents and for the poles $1.90 per cord, loaded on barges. About 28,595.3 cords of brush and 797.6 cords of poles were received under this contract.

The mat work was much retarded by the failure of the contractors to furnish material in sufficient quantities to keep a full force employed. Much more work could have been done had there been plenty of material. For this loss of time the contractors are mainly responsible. While brush and poles had to be hauled a longer distance than usual on account of a high stage of water, rendering brush on the lowest bars inaccessible, and some difficulty was experienced in procuring labor on account of quarantine restrictions, still these obstacles could have been overcome by a proper effort on the part of the contractors. Delays from the above cause have occurred before, but there has been an unusual loss of time from this cause the present season. As the low-water period during which revetment work can be successfully prosecuted seldom exceeds six months in the year, and includes two of the most unhealthy months, when malarial fevers are the most prevalent and there is a scarcity of labor, the necessity of utilizing every day of the working season becomes imperative.

A modification of the specifications, making it to the pecuniary interest of the contractor to be prompt in his delivery, by charging him with all the expense of the towboats while waiting for barges when the rate of delivery is less than the contract requirements, would in future materially reduce delays from this cause.

Conditions attending work.—Not as much work has been accomplished as was projected, due to several causes: The unusual high stage of water during the working season, failure of the contractors to furnish brush commensurate with the demands of the work, interruptions to labor due to quarantine restrictions, and the shortness of the working season, which, for doing mat work with safety, closed January 15, 1899, the river then having reached 25 feet on the Greenville gauge.

Only one revetment party was in the field, as there are not sufficient mat boats and barges for an additional outfit, and while all the work projected might have been finished under the most favorable conditions, with an abundance of labor and material and a long working season, it became evident in November, at which time 5,600 feet of mattress work remained to be done to complete the Greenville work, that it would be impossible to finish this and in addition do the repairs at Ashbrook Neck, Lake Providence, and Delta Point.

The importance of beginning work as early as practicable and crowding the work during the low-water season has been exemplified the past season. Unavoidable delays will occur. If possible, all mat work should be finished while the river is below half stage.

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The revetment party was under the direct charge of Mr. George C. Thomas, superintendent of construction. Detailed statements of the cost of the various items of work are submitted herewith.

Cost per unit of work done, Greenville Harbor, season 1898–99.

	Units.	Pay roll.	Subsistence.	Material.	Total.	Cost per unit.
Channel mat.....squares..	14,666	$16,721.40	$3,183.74	$43,613.72	$63,518.86	$4.333
Pocket mat.....do....	2,842.7	2,656.06	506.06	8,239.95	11,402.07	4.011
Dressing slope.....linear feet..	5,160	1,659.71	233.52	.....	1,893.23	.367
Paving slope.....squares..	5,881.7	4,939.75	940.71	29,015.59	34,896.05	5.932
Grading (hydraulic)...linear feet..	5,160	3,008.09	521.96	683.97	4,214.02	.817
Minor repairs.....	.....	1,732.16	120.76	2,458.98	4,311.90	.....
Towing.....	.....	4,188.51	760.74	2,576.60	7,525.85	.....
Superintendence.....	.....	2,765.84	143.01	.....	2,908.85	.....
Property purchased.....	.....	.....	.....	.....	2,179.84	.....
Sundries.....	.....	.....	.....	190.17	190.17	.....
Memphis office.....	.....	.....	.....	.....	4,120.20	.....
Total.....	.....	37,671.52	6,410.50	86,778.98	137,161.04	.....

Total cost of work done.....		$137,161.04
Less cost of minor repairs.....	$4,311.90	
Less cost of Memphis office.....	4,120.20	
Less towage (overhaul on brush).....	485.31	
		8,917.41
Net amount expended on new work.....		128,243.63

$128,243.63 ÷ 5,073 (linear feet of work) = $25.28 per linear foot.

Material expended per unit of work, Greenville Harbor, season 1898–99.

[Channel mat, 14,666 squares.]

Material.	Quantity.	Per square.
Brush.....cords..	21,617	1.474
Poles.....do....	760	.052
Stone.....cubic yards..	10,688	.72
Wire strand:		
½-inch.....pounds..	66,149	4.51
⅜-inch.....do....	33,785	2.30
¼-inch.....do....	91,662	6.25
Wire:		
Galvanized, No. 12.....do....	28,892	1.97
Silicon bronze.....do....	8,526	.58
Spikes.....do....	700	.048
Clips, Magnolia.....number..	5,000	.34
Staples.....pounds..	1,760	.12

[Pocket mat, 2,842.7 squares.]

Brush.....cords..	4,197.8	1.474
Poles.....do....	126	.044
Stone.....cubic yards..	2,133	.75
Wire strand:		
⅜-inch.....pounds..	6,870	2.416
¼-inch.....do....	17,784	6.25
Wire:		
Galvanized, No. 12.....do....	5,546	1.95
Silicon bronze.....do....	1,547	.54
Staples.....do....	340	.12

[Bank paving, 5,881.75 squares.]

Stone.....cubic yards..	18,217.79	3.10

[Minor repairs, 24.3 squares.]

Dikes, 304 by 8 feet:		
Brush.....cords..	237	9.75
Stone.....cubic yards..	300	12.36
Paving, 336.6 squares, stone.....do....	1,009.83	3

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Material expended per linear foot completed work, Greenville Harbor.

[Amount of work completed, 5,073 linear feet.]

Material.	Quantity.	Per linear foot.
Brush ..... cords..	23, 720. 3	4. 67
Poles ..... do....	886	.174
Stone ..... cubic yards..	31, 038. 81	6. 12
Wire strand:		
¾-inch ..... pounds..	66, 149	13. 04
⅜-inch ..... do....	40, 655	8. 01
½-inch ..... do....	109, 446	21. 57
Wire:		
Galvanized, No. 12 ..... do....	34, 438	6. 79
Silicon bronze ..... do....	9, 073	1. 79
Spikes ..... do....	700	.14
Staples ..... do....	2, 100	.414
Clips, Magnolia ..... number..	5, 000	.99

Cost per unit of work done, Lake Providence Reach, season 1898–99.

	Units.	Pay roll.	Subsistence.	Materials.	Total.	Cost per unit.
Channel mat ..... squares..	1, 218	$2, 276. 26	$520. 05	$4, 067. 63	$6, 863. 94	$5. 635
Pocket mat ..... do....	191. 7	486. 68	111. 06	628. 98	1, 226. 72	6. 399
Towing	.....	800. 77	156. 96	868. 80	1, 826. 53	.....
Superintendence	.....	431. 66	35. 87	.....	467. 53	.....
Grading (hydraulic) .. linear feet..	400	335. 05	80. 83	73. 00	488. 88	1. 221
Sundries	.....	.....	.....	.....	136. 77	.....
Memphis office	.....	.....	.....	.....	128. 84	.....
Total	.....	4, 330. 42	904. 77	5, 638. 41	11, 139. 21	.....

Total cost of work done		$11, 139. 21
Less amount charged to levees, towing	$100. 00	
Less cost of Memphis office	128. 84	
		228. 84
Net amount expended		10, 910. 37

$10,910.37 ÷ 400 linear feet work done = $27.275 per linear foot.

Material expended per unit of work, Lake Providence Reach, 1898–99.

[Channel mat, 1,218 squares.]

	Quantity.	Per square.
Brush ..... cords..	1, 717	$1. 41
Poles ..... do....	60	.50
Stone ..... cubic yards..	1, 156. 04	.95
Wire strand:		
¾-inch ..... pounds..	12, 560	10. 31
⅜-inch ..... do....	5, 583	4. 58
½-inch ..... do....	7, 381	6. 06
Wire:		
Galvanized, No. 12 ..... do....	1, 827	1. 50
Silicon bronze ..... do....	731	.60
Staples ..... do....	85	.07
Clips ..... number..	437	.36

[Pocket mat, 191.7 squares.]

Brush ..... cords..	267. 4	$1. 40
Stone ..... cubic yards..	200	1. 04
Wire strand:		
¾-inch ..... pounds..	1, 000	5. 20
½-inch ..... do....	1, 168	6. 09
Wire:		
Galvanized, No. 12 ..... do....	237	1. 42
Silicon bronze ..... do....	115	.59
Staples ..... do....	15	.078

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Amount of material expended per linear foot of work.

[Amount of work done, 400 linear feet.]

	Quantity.	Per linear foot.
Brush.....cords..	1,986.4	$4.96
Poles.....do....	60	.15
Stone.....cubic yards..	1,356.04	3.39
Wire strand:		
½-inch.....pounds..	12,560	31.40
⅝-inch.....do....	6,583	16.40
¾-inch.....do....	8,549	21.37
Wire:		
Galvanized, No. 12.....do....	2,100	5.25
Silicon bronze.....do....	846	2.11
Staples.....do....	100	.25
Clips, magnolia.....number..	437	1.09

STONE.

Under the contract with Edmond Ligon & Co., to deliver 30,000 cubic yards of stone, loaded on barges at the quarry on the Little Red River, on May 1, 1898, there had been received 11,743 cubic yards, of which 8,155 cubic yards had been unloaded on the bank at Greenville as a reserve. From May 1 to June 19 there was received 11,112 cubic yards, of which 3,884 cubic yards were allowed to remain on barges for use later in the season.

The period during which Little Red River was navigable for loaded barges was from March 13 to June 10.

The total amount of stone furnished under this contract was 22,855 cubic yards, at 47.9 cents per cubic yard.

The cost of towing to Greenville was $19,844.73. This included cost of repairs to fit for service and necessary repairs during the season of the towboats and barges.

Steamer *Emma Etheridge*	$427.75
Steamer *Titan*	243.59
Steamer *Vedette*	173.72
Barges of Second district	625.63
	1,470.69

making the cost of towing 86.8 cents per cubic yard; cost of unloading on bank, 12.23 cents per cubic yard; cost of reloading on barges at Greenville, 23.6 cents per cubic yard; total cost, $1.7053 per cubic yard.

The cost of towing is greater than it would be under ordinary conditions, due to the failure of the contractors to load with sufficient rapidity to keep the towboats constantly employed, causing delays at the quarries waiting for tows, with the attendant expense.

These delays increased the cost of towing nearly 25 per cent. As these quarries are now the property of the United States, and the towing facilities can be regulated to the output, it is believed that stone can be towed at a very much less cost in the future.

PLANT.

New plant.—The only new plant was the steel hull towboat *Arthur Hider;* length, 140 feet; beam, 30 feet; depth of hold, 5½ feet; main engines, 18 inches by 7 feet; four 5-flue boilers, 42 inches in diameter and 26 feet long; wheel, 20 feet in diameter; length of bucket, 21 feet; width of bucket plank, 30 inches; steam steering and shifting apparatus; auxiliary boiler; electric lights. On her trip to Greenville, before being delivered, she broke the piston head and follow head of the starboard engine. This defect was remedied by the contractor. After being accepted she met with a similar accident January 25. These parts were made stronger, and since then her performance has been quite satisfactory.

High water protection of levees.—At the close of last report, May 1, 1898, there were still in service three quarter boats and three barges. These were returned to the fleet as soon as the danger was past.

The only calls the present season for plant were at Reed Levee, Louisiana, where two quarter boats and four barges were sent March 13, and at Shiloh, Miss., where a protection levee was built. One barge, with material, was sent here on April 15, and two quarter boats and one barge, with material, on April 17. All this plant has been returned.

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Cost of repairs to plant, Third district, improving Mississippi River, May 1, 1898, to May 1, 1899.

Number or name.	Cost.	Remarks.
Steamer—		
Emma Etheridge	$1,419.65	New gallows frame; foundation under capstan; new rudder; repairs to wheel; raising boilers and bracing under same; new deck beams and deck in forecastle; hog chain and braces repaired; new deck in fire room; new pitman and crank brasses; pump piston and piston head; new furnace; all pipe work and machinery overhauled, and ordinary repairs during the year.
Authur Hider	619.57	Buckets on wheel shifted; platform for lines in deck room; 6 treatles and 1 stepladder; extra bins and shelves in pantry made; repairs to bulkhead and doors in engineer room; new kevel; plate glass in front cabin; new piston, follower, and cylinder head, and packing for starboard engine; water gauges lowered; changes in steam pipe; refacing safety valves, and repairs during four months' service.
Vedette	157.07	New pitman; repairs to wheel; settee for pilot house; new cap for steam chest; lining up engines; overhauling machinery, and ordinary repairs during the year.
Meter	49.60	Repairs to wheel and roof.
Tug Parker	768.74	Docked. New plank in side; repairs to roof, nosing, plank-sheer; new kevel, wheel, mud drum, rod braces, and furnace; calking, and ordinary repairs during the year.
Grader—		
No. 1	870.44	Docked. New rake; 2 pieces in gunwale; new deck under auxiliary boiler; new set of flues put in auxiliary boiler; calking; ordinary repairs to machinery during working season.
No. 3	959.87	Docked. New rake; 6 pieces gunwales; 22 plank in the bottom; 2 kevels; 1 set of hitts; hog-chain braces; deck repaired and hull calked; extra rods to hold steam ends of pumps together; new rocker shafts for main engines; vacuum and feed pumps and other machinery overhauled; new set of flues for auxiliary boiler.
No. 77	4.18	Minor repairs.
Mattress boat—		
No. 26	25.94	Calking above light water; repairs to skids, outriggers, and shifting rigging.
No. 27	19.58	Do.
No. 188	5.44	Minor repairs.
Machine shop, No. 222	32.30	Patching deck; bed timbers under dynamo; repairs to roof.
Carpenter shop, No. 78	9.21	New timberheads, battens in hold, and braces under roof.
Model barge—		
Apache	6.30	Battens in hold.
Maricopa	19.84	Calking lower seams.
Nez Perce	37.20	Calked above light water.
Square barge—		
No. 79	167.96	Docked. Rakes repaired; 2 timberheads; sides and rakes calked.
No. 80	309.21	Docked. New rakes; 6 timberheads; sides and rakes calked.
No. 82	284.38	Docked. Rakes repaired; half-way pieces in side; sides and rakes calked.
No. 83	320.45	Docked. New stems; about one-half new rake at each end; 8 pieces of gunwale; bottom, sides, and rakes calked.
No. 85	2.25	One timberhead.
No. 108	207.44	Docked. New rakes and gunwales at ends; 4 timberheads; calked.
No. 111	202.44	Docked. New lower gunwales and rake; 1 timberhead; calked.
No. 135	16.25	Five timberheads.
No. 137	13.02	Lower seams calked.
No. 535	24.99	Calked above light water.
No. 553	24.68	Do.
No. 554	8.95	Hole in rake repaired
No. 556	15.59	Two rake planks put in and lower seams calked.
No. 558	26.93	Four rake planks and calking above light water.
No. 560	26.30	Calked above light water.
No. 563	7.51	Battens in hold.
No. 210	308.44	Docked. New rakes half way; repairs to sides; calking sides, rakes, and butts on bottom.
No. 224	431.72	Docked. 26 floor timbers; 31 side frames; 80 planks on rakes; sides and rakes calked.
No. 225	319.96	Docked. New plank put in sides and rakes; 6 timberheads; deck sheathed; sides and rakes calked.
No. 226	184.85	Docked. New plank put in sides and rakes; 6 timberheads; sides and rakes calked.
Quarterboat—		
No. 16	102.50	Battens in sides; lower seams calked; repairs to doors; windows and bunks for survey party.
No. 17	2.10	Coal box repaired.
No. 19	34.99	Repairs to guards; 4 timberheads; repairs to bunks; lower seams calked for survey party.
No. 31	49.93	Repairs to scales, blue-print frame, drawing boards, and furniture.
No. 38	144.44	Docked. 14 pieces of new gunwales; 3 timberheads; rakes sheathed; sides, rakes, and butts in bottom calked.

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Cost of repairs to plant, Third district, improving Mississippi River, etc.—Continued.

Number or name.	Cost.	Remarks.
Quarterboat—		
No. 86	$37.90	Repairs to rail on guards; lower seams calked.
No. 88	17.54	Lower seams calked.
No. 154	39.38	Battens in rakes; 2 timberheads; pumps repaired; lower seams calked.
No. 155	190.35	Docked. New rakes and gunwales at corners; rakes and 3 seams on sides calked.
No. 156	216.61	Do.
No. 157	25.80	Four timberheads; roof repaired.
No. 158	129.78	Repairs to guards, doors, and windows; ranges rebuilt, and pump repaired.
No. 159	33.26	Repairs to roof.
Dry dock	188.62	New tank to supply feed pumps; repairs to corner gunwales and to main gate.
Pile driver No. 34	15.19	Four timberheads.
Lake Providence	9.65	16 outriggers for mat boat.
Launch Oneata	23.66	Plank in sides; rail and rail stanchions; calking and repairs to machinery.
Coal boxes	34.73	32 repaired.
Greenville Harbor	588.40	Repairs to tools and machinery of grader while in service; 2,200 clevises made.
Skiffs	16.96	3 skiffs repaired.
Rope (wire cable)	31.65	Cleaning and oiling same.
Surveys	22.88	Stakes and bench marks.
Telephones	5.55	Ordinary repairs.
Levees	175.33	Office furniture; 4 map cases, and drawing boards.
Property	190.72	Repairs to kitchen outfits.
Pumps	417.50	162 repaired.
Second District plant.		
Steamer Titan	63.32	Repairs to wheel; sheathing deck in fire room; rail on roof repaired.
Square barge—		
No. 9302	42.21	Calking and repairing hole in side.
No. 9308	43.00	Calking above light water.
No. 9311	33.53	Do.
No. 9312	100.20	Sides straightened; new gunwales under tie chains; 2 new gunwales; calked above light water.
No. 9313	9.70	Hole in rake repaired.
No. 9314	16.05	New kevel and repairs to deck.
No. 9315	47.48	Calking side and repairs to rake.
No. 9316	36.17	Calking sides and rakes.
No. 9318	51.04	Docked. Hole in bottom repaired; knuckle seams calked.
No. 9319	81.88	Sides straightened; calking sides and rakes.
No. 9322	41.13	Calking sides and rakes.
Wages, cooks and waiters.	735.17	
Superintendence	1,608.33	
Total	13,462.77	

Approximate value of plant belonging to the United States and used in the third district, improving Mississippi River, May 1, 1898, to May 1, 1899.

Class of property.	Number.	Approximate value.	Class of property.	Number.	Approximate value.
Steamer Arthur Hider	1	$37,450	Floating dry dock	1	$11,000
Steamer Emma Etheridge	1	7,000	Floating pontoon docks	2	450
Steamer Meter	1	3,400	Floating stern dock	1	100
Steamer Vedette	1	4,500	Pile drivers and outfits	2	1,400
Tug Parker	1	3,500	Skiffs	26	390
Mat boats Nos. 26 and 27	2	7,000	Dredge Menge	1	8,500
Mat boats, old	2	300	Dump scow No. 2	1	0
Headquarter boat No. 31	1	3,500	Calking flats	3	90
Quarter boats	14	14,900	Tools and appliances	.....	2,000
Store boat	1	1,000	Office furniture and safes	.....	250
Hydraulic graders	2	11,000	Surveying instruments	.....	2,000
Hydraulic graders, small	1	800	Machine shop and outfit	1	4,000
Model barges	5	700	Carpenter shop and outfit	1	3,000
Square barges	15	27,000			
Do	22	7,700	Total	109	162,930

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The cost for the twelve months of caring for the above plant, property and outfit thereon, was $20,486.24.

The average number of employees engaged in the service was 38.

The average daily cost of subsistence for employees engaged in superintendence and repairs to plant was 32 cents.

Very respectfully,

ARTHUR HIDER, *Assistant Engineer.*

Capt. H. C. NEWCOMER,
Corps of Engineers, U. S. A.

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 10, 1899.*

CAPTAIN: I have the honor to submit the following report of operations in the Lower Yazoo Levee district during the year ending May 1, 1899:

In accordance with the instructions contained in your circular letter dated August 10, 1898, on September 1 I assumed local charge of the levees from the Coahoma County line to Greenville, in addition to those south of that point already under my supervision, thus consolidating the district under one local administration. Owing to the difference in enumeration of alignment above and below Greenville, and the separate organization up to the time the change was made, in much of this report I will necessarily have to consider the district as divided.

The combined district, reaching from the Coahoma County line to Kigers, on Eagle Lake, is about 187 miles in length, and contains at the present time, by way of the Huntington Short Line, levees aggregating 26,883,717 cubic yards of earth. During the year 2,775,914 cubic yards have been added to the line by the United States Government, and 670,961 cubic yards by the Levee Board.

The levees that will be abandoned by new work, part under contract, but nearly completed, are 96,800 feet in length, containing approximately 2,086,594 cubic yards, as follows:

	Cubic yards.
Huntington and Offuts line, stations 3280–3880 (436–445 L.)	1,410,232
Levee, stations 4233–4300 (460 L.)	137,862
Levee, Greenville, stations 4484–4544 (478 L.), (Levee Board)	200,000
Locust street, Greenville (480 L.) (Levee Board)	13,000
Below Leota, stations 1999–2108 (513–514 L.)	105,000
Baleshed, stations 3170–3184 (537 L.)	20,000
Shiloh, stations 4154–4195 (555 L.)	83,500
Albemarle, stations 4800–4870 (569 L.)	117,000
Total	2,086,594

This does not include lines abandoned by the new unfinished Hays and Albemarle loops, but does include those abandoned by the high-water protection loops. The former will not be completed until some time during the autumn of the present year.

Two grades have been been recommended for future construction, one 3 feet above the high water of 1897 and the other 6 feet above the same datum, the latter to be attained as practicable after bringing the line generally to the first, with banquette, etc., as stated in reports on gauges and grades November, 1898, and February, 1899.

The estimate for the 6-foot grade for the entire district for standard levee, with banquette, is approximately 21,500,000 cubic yards.

I agree with you in the advisability of increasing the crown and slope of the standard levee if funds can be obtained to insure the enlarged dimensions and section, but the figures given above are based on the standard as heretofore considered.

The approximate yardage and funds required to raise the levees in the district to a grade 3 feet above the 1897 high water, with standard section, are as follows:

Above Greenville.

	Quantity.	Price.	Amount.
	Cubic yds.		
New Riverton loop	215,000	$0.14	$30,100
Enlargement, stations 2200–2380	70,000	17	11,900
Enlargement, stations 2880–2900	5,000	17	850
Enlargement, stations 3930–4168	144,000	17	24,480
Banquette, station 0–4500	270,000	11	29,700

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Below Greenville.

Enlargement Station 0–5585	2,035,000	.15	305,250
Baleshed Loop	200,000	.12	24,000
Banquette Station 0–5200	800,000	.10	80,000
Total	3,739,000		506,280

Average price for all work equals about 13.5 cents per cubic yard.

The enlargement of the levee above Greenville from Station 2092 to 2200 and Station 2380–2616 is now under contract by the levee board to the 3-foot grade; also below Greenville from Station 3440 to 3485 and 3505 to 3551 to 2 feet above 1897 grade.

The enumeration used in this report is the same as heretofore employed. The enumeration of new survey above Greenville will not be adopted until profiles have been completed showing relative distances, etc.

At the time the last Annual Report was submitted the high water of 1898 had fallen to 36 feet on the Greenville gauge. During May it rose again slightly, but no further flood stage occurred. The wave that was at some points in the district higher than that of 1897 passed off without causing a break.

At the present time the levees above Greenville are practically up to a grade 3 feet above the high water of 1897, with the following exceptions:

Stations.	Number of stations.	Above high water, 1897.	Remarks.
2092–2137	45	About 1.5 feet	Under contract with levee board.
2137–2330	193	2 to 2.5 feet	Do.
2330–2612	282	1.5 to 2 feet	
2880–2900	20	2.5 feet	
3880–3930	50	1 foot	Under contract.
3930–4178	248	1.5 to 2 feet	
Total	a 838		

a About 16 miles.

Much of this is but half a foot below 3-foot grade. There are numerous short reaches not included in the above where traffic has worn from half a foot to a foot off the top of the levee.

Above Greenville about 101,199 cubic yards still remain to complete outstanding contracts.

Below Greenville, of the contracts in force, about 666,395 cubic yards remain to be put up. When completed the line will be to the 3 feet above 1897 grade to Station 2108, about 40 miles. From Station 2108 to Station 5585, on Eagle Lake, the height of the levee varies, but it has been generally raised by topping where needed from 1.5 feet to 2 feet above the highest water.

CAVING BANKS.

There has been little caving in the district above Greenville during the year. At Waxhaw the bank is wearing away, but the levee is still over 1,200 feet from the river, and at the present rate of caving two or more years will elapse before a new line will be necessary. At Riverton, Stations 1592 to 1649 (400 L), the river is within 400 feet of the levee, having caved actively during the fall and winter. A survey and estimate have been made for a new line, which will be needed in less than a year.

The river bank is very near the levee at Eutaw and Jenkins, but slight change has occurred during the year. As a very little caving at these latter points will cause the destruction of the levee unless there is some change in the direction of flow after high water, it may be necessary to construct small loops a short distance back from the river bank.

In the bend above Huntington, and at that place also, caving is active when the water is under the bank, but it will not be a source of danger when the Huntington Short Line is finished, which should be by June 15.

At Greenville the breaks in the revetment have been repaired, and though the levee is at many points directly on the river bank it is considered safe until further deterioration of the revetment work threatens its stability.

At Warfield, Station 288 (485 L.), the water in the chute is encroaching on the levee slowly, being about 275 feet from the same at the present time.

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In the vicinity of Longwood the bank is caving, but the material is hard and the rate of change slow.

Below Leota the river has approached very nearly the old levee. The completion of the new loop insures a safe line should the old cave off.

The bank continues to cave in the Island 92 reach, above Duncansby, but it is still over 1,500 feet from the levee at the nearest point.

At Baleshed, Station 3170, where the temporary loop has lately been constructed by the Government, the bank will probably continue to cave, necessitating the construction of a new levee located over half a mile back from the present line. Much depends here on the position of the channel after high water. A continued tailing of the Homochitto Bar will simplify the problem and reduce the ultimate cost of new lines.

But little change has occurred at Shipland. The bight of the bend has moved downstream, but new departures may develop on the recession of the present high water that will produce caving again higher in the bend.

At Fitlers a deep pocket has been made above the landing, caused to a great extent by the excessively firm and tenacious black clay forming a point just below. There is active caving below this point. Should the point be destroyed by the current, as I anticipate, the river will form a great bend, necessitating the construction of long and expensive back lines of levee.

From Hays to Shiloh the caving continues; at the latter point, even during high water. A new levee half a mile back is under construction in this reach and two protection loops have been built to keep out the water until its completion. One of the loops was constructed during the present high water on very wet ground with much difficulty.

From Albemarle to the upper end of the new Chotard Levee of 1897–98 the bank continues to cave. The new (levee board) loop being incomplete when the water commenced rising, it was necessary to put up a temporary protection levee over a mile long (7,000 feet). This the levee board did at a considerable cost, owing to unfavorable conditions.

This bend continues to cave to below Chotard, but with the completion of the levee-board loop at Albemarle it will probably not reach the main levee for some years. The material composing the river bank is very light; consequently the caving is very rapid and will continue to be so unless more tenacious material is encountered or there is some change in the regimen of the river in the vicinity, varying the point of attack of the current.

It is not a great distance from the levee to Steeles Bayou which drains a large section of country directly back of the levee, from Lakes Swan and Washington (back of Leota) into the Yazoo near its old mouth. Should the river cut its way into this bayou, the point of intersection would probably be the terminus of the levees in this district, unless an immense sum of money was expended in turning Steeles Bayou into Deer Creek or some other channel east of its present bed.

At Brunswick the bank continues to cave; at its present rate of progress it will probably be necessary to construct a new line there in the course of two or three years. In the Brunswick reach the same conditions obtain as in the Chotard bend; light, sandy soil, rapid caving, etc.

CONSTRUCTION.

The past season has been very unfavorable for levee construction. The rainfall during the year has been above the mean, as shown in the accompanying table of precipitation. It has also been so distributed over the dry months that the ground has been kept constantly saturated, and the depressions, borrow pits, etc., generally dry in the summer, filled with water. For the dry months from August to November, inclusive, the mean given in the table is 11.91 inches, while during the same period in 1898 we have 24.41 inches, or more than double that amount. This, in conjunction with a winter of surpassing severity, has proved very disastrous to levee interests. Much of the work in this district that would have been completed under normal weather conditions had to be temporarily abandoned during the high water after topping incomplete stations.

Yellow fever of a mild type prevailed again during the autumn months of 1898, but with less detriment to levee operations than in previous years.

A circular was sent from this office to the contractors working in the district, advising them to obtain sufficient subsistence supplies for labor and mules for the probable quarantine period, and urging local camp quarantine, in order to avert stopping operations while general quarantine was in force. This advice was generally acted on and but little delay or trouble experienced.

The Shippey and Kilpatrick outfit that had been employed on the Illinois Central Railroad east of Clarksdale was delayed by the quarantine in getting to work on the new loop at Hays Landing. No outfit that was at work suffered much incon-

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venience other than shortage of labor, which generally occurs in the fall of the year while the cotton crop is being gathered.

Unfinished work.—Of the 1896 contracts above Greenville two were incomplete at the time of submitting the last annual report, as follows:

Stations 300–400, 372 L., enlargement, Ernest Hyner, contractor.

Stations 500–600, 376 L., enlargement, E. B. Mantle, contractor.

These have since been finished.

The 1897 contracts paid from the $800,000 continuous allotment of 1896 have all been completed, as shown in accompanying statement, with the following exceptions:

Stations 2700–2800, 419 L., enlargement, McCadden & Roach, contractors.

Stations 3329–3360, 436 L., new loop, McIntyre & Howard, contractors.

Stations 3880–3930, 445 L., enlargement, Arnold & DeGaris, contractors.

Stations 4150–4200, 460 L., enlargement, Arnold & DeGaris, contractors.

Stations 4400–450 0, 476 L., enlargement, T. Sullivan, contractor.

These will be finished with the exception of the two of Arnold & DeGaris, which may be abandoned.

Below Greenville all the incomplete work of 1897 has been finished, but some of the 1898 contracts that were to have been complete February 1, owing to the very unfavorable season have been extended to December 1, 1899.

Huntington Short Line (435 L.).—The Huntington Short Line, of which section from Stations 3329 to 3360 still remains partly incomplete, was constructed for the purpose of eliminating the long and dangerous levee which follows the river bank by Huntington and Offuts, a total distance of about 11¼ miles, and obtaining a more permanent location of less than half the length (4¼ miles), where frequent temporary locations and expensive enlargements would not have to be resorted to. The new line throws out 8,863 acres of land, a large portion of which (5,868 acres) is cultivated.

Naturally there was much opposition to this location by the landowners whose property would practically be made worthless so soon as the existing front line caved off or was overtopped by a great flood. This work was advertised and the contracts let in six sections July 21, 1897. Much litigation was indulged in between the levee board and the landowners, but no steps were taken to prevent construction until January 24, 1899.

Black Bayou, which the new levee crosses at Station 3443, is the natural drain for most of the country thrown out. During construction this bayou was closed (December 15, 1897), thus cutting off all drainage and damming the rain water, which eventually was backed up on the unfinished section, Stations 3329 to 3360, preventing further progress. In order to obtain drainage and complete the line the construction of a siphon was proposed of sufficient capacity to get rid of the accumulating water. A contract was entered into, but owing to quarantine restrictions it was impossible to get the required pipes, valves, etc., until late in the season. In the meantime the water had risen considerably on the inclosed lands, backing up into the pits on the unfinished work and saturating the soil on the center line.

As the time for the completion of the siphon contract had expired with no prospect of obtaining the materials for its construction, should an extension be granted, it was deemed best to cut the levee at the bayou crossing, thus getting rid of the impounded water. This was done with teams and scrapers (the final cut being made with dynamite December 6, 1898) at a cost of $1,012 or about 27 cents per yard. The desired relief was obtained and the construction of the unfinished gap continued until nearly completed, as shown in accompanying statement.

January 24 of the present year counsel for the landowners thrown out by the short line obtained an injunction from a judge of the supreme court of Mississippi preventing the refilling of Black Bayou. April 22 this injunction suit came to trial before the local chancellor and resulted in the dissolution of the injunction. A restraining order was then obtained from the Federal court which prohibits the closing of the bayou until the second Monday in May.

When all legal restrictions are removed the bayou will be closed and the short line will become the permanent controlling levee.

While the damage to the interests of the local resident and property holder is recognized, the great benefit to be derived from permanent lines like the Huntington short line is so far reaching that this damage must be very great to balance it.

Permanence and economy of maintenance and future enlargement are very strong reasons for a radical departure in the location of levees in the future. Not without regard to the interest of riparian owners, for whose benefit the levee is constructed, but having in view the necessity at all times of damaging the few in order that a permanent and reliable system of levees may be economically obtained and maintained for the greater benefit of the many. As the flood plane rises with the perfection of the levee system new lines become more expensive, and temporary or tentative locations will surely incur expense beyond the power of the State and the intention of the Government to contract.

Stop Landing Levee.—At the time the last report was submitted the work on the

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main Stop Landing loop had been abandoned temporarily and the high-water fight made on a small protection levee. The main line where it crossed the extension of the lower end of Lake Bolivar (probably the old bed of the lake), Stations 3201–3215 (435 L), had sunk to a very great extent, as stated in the last report, and continued to sink as new earth was placed on it. September 20, 1898, a day force of fifty teams was employed, at $4 per team per day, including all labor, etc., and the levee brought to grade. After obtaining the required height four stations sank, but not to an alarming extent, the greatest subsidence being 3½ feet. The material in the slope and base of the levee on the river side was pushed out and up by the weight above. In order to control this bulging and sloughing tendency and produce permanent equilibrium, a berm was constructed containing about 6,600 yards in front of the sinking stations, with crown about 83 feet wide and about 12 feet below top of levee. This berm had the desired effect, and the levee was raised to a grade 4½ feet above the high water of 1897. Since completion there has been a more uniform sinking; no bulging or sloughing. At the present time the crown is about 4 feet above 1897 water. Prior to the construction of this berm the foundation soil was tested to 50 feet below the surface of the ground, and found to be a soft, slushy blue mud that had no stability under pressure. The cost of completing this sinking levee, requiring about 32,463 cubic yards, including the berm, was $12,407.70, including engineering expenses, or about 40 cents per yard. Taking into consideration the very long haul—over 1,000 feet—and bad season, this cost is remarkably low.

Machine work.—The enlargement contract, Stations 1400–1500 (500 L), was completed during the season, with the exception of about thirty stations which it was impossible to build, owing to water in the pits and the great difficulty of obtaining drainage. Beyond the old pits the material was saturated, and though it was possible to handle it with shovels, teams could not be employed at all—the mules in a short time would loosen the soil, and sink in it to their shoulders. The haul was too great for economical wheelbarrow work. In order to continue construction the subcontractor, James Cary, devised a hoisting machine that was used, commencing November 24, 1898, in conjunction with cars, and which proved a failure owing to the many breakdowns, due to faulty design. Under the conditions existing at the time it would have worked to advantage if the framework had been strong enough to resist the strains to which it was subjected, as demonstrated in the intervals between the breakdowns. The great difficulty experienced was the constant breaking of the frame supporting the carrying apparatus and car bodies.

New pits were made just beyond the old and a track laid thence to the base of the enlargement, with the necessary switches, etc. Spanning the proposed enlargement was a frame composed of two uprights—one on top of the levee and one beyond the base of the slope—supporting a trussed beam that in turn supported the carrier and cable on which it traveled. This framework rested on tracks at base and crown of levee, and was moved as the enlargement was carried forward. A hoisting engine, also on a track, moved slightly in advance of the frame. The method of operating was as follows:

The cars were filled by shoveling the earth into them by hand directly from the pit. They then traveled by gravity beyond the center of the old pit, and from there were pulled by mules to the toe of the slope of the enlargement, under the hoisting device. The carrier clutch was lowered, fastened to the car body, then raised by the hoisting cable, carried forward and dumped at the desired point, and returned to the trucks to be refilled. The accompanying sketch[1] and following extract from the report of Inspector J. S. Allen give more fully the details of the work and the appliances employed:

"December 15, 1898. I have the honor to mail you, under separate cover, drawing of the machine in use by subcontractors, Cary Brothers, on Longwood line, and to submit herewith a report as to the construction and working of the same: It consists of a beam 90 feet long made of six 2 by 12 inch pine planks placed flat on each other and firmly bolted, the planks being so cut as to break joints at about every 3½ feet. This is strengthened by five truss-rods placed as follows: One under each lower corner, on each side, and on top. Under the bottom of beam is a 1½-inch wire cable passed around each end and drawn taut by turn-buckles on top and at each end. The beam is raised to a distance of 25 feet above the crown of the levee and takes about a 4 to 1 slope to its support 10 feet outside of the slope stakes. On the wire cable runs a trolley operated by a double cylinder 20-horsepower hoisting engine placed on crown of levee, the car bodies being thereby raised and carried up the slope to any point desired. The drawings will show the mode of raising and dumping the same, as well as the system of tracks by which they are brought from the pits, which at present are distant about 600 feet. The cars are 6 feet long, 4 feet wide, and 2 feet deep, giving a capacity of 48 cubic feet. Cary has under construction, on the ground, new cars with a capacity of 2 cubic yards, with end

[1] Omitted.

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gates that open automatically upon dumping. These, however, are for the other machine that he contemplates putting up, and which will be built on stronger lines than the present one. The cars are all of pine, but should be of seasoned oak or of iron. In a haul of this length the machine will keep 22 cars busy, they being loaded by men, 30 of them being employed on an average, distributed as follows: Eighteen loading cars, 4 drivers, 3 track men, and 5 at the machine, including the engineer and foreman. I find that since work began they have handled 11 cubic yards per man, but for a week or ten days after the start they did poor work and stopped often to make changes and to correct defects. I have hurried them lately and find that they now move about 35 cars to the hour, which would give about 15 yards to the man or 470 yards for the machine. Since I obtained my data for drawings they have made several improvements, notably in the arrangement of the first pulley from the engine. He will also change the place of clutch for the other machine so as to accommodate the larger cars, and open the end gate upon dumping."

Mr. Allen estimates that under favorable conditions 470 cubic yards can be moved per day by this machine. Under the conditions that existed at Longwood, with 30 men and 4 teams, this will be about $60 per day, including all expense, or about 13 cents per yard.

The shrinkage required on this machine work was at first 20 per cent, but afterwards reduced to 15 per cent. in view of the fact that in emptying the material fell in the first layers of the enlargement ten or fifteen feet, tamping itself very considerably. Stakes were set for the purpose of determining the shrinkage, but the rain washed the top of the levee down to such an extent that no comparison or report could be made other than a general statement that the material in this machine work seems to have shrunk very little. It may be, though, that the shrinkage is slow, and in time this untamped work will show considerable change in section, as the wheelbarrow work in Arkansas did during the flood of 1897, four years after construction.

It is the purpose of the subcontractor to use a steam shovel or scraper for filling the cars at the pits, thus doing away with the slower and more expensive method of shoveling by hand. He is also experimenting on a scraper worked by cable and steam that will place the material directly in the levee without resort to cars or other intermediate appliances.

As the levees are forced back from the higher ridges by caving banks and become of greater section and height, the question of their construction by machines of greater magnitude and efficiency than the wheel scraper becomes very pertinent, and their use raises questions of change in specifications—shrinkage, perhaps rolling, etc.—that are very important. To my knowledge three methods besides the ordinary ones of teams and wheelbarrows have been employed in the construction of levees on the Lower Mississippi River. They are by New Era graders, by the machine described above, and by hydraulic dredges. The latter is not feasible in this district, or indeed at any point above the mouth of Red River, and very few below on the Mississippi River. Levee building by means of hydraulic dredge requires the levee to be near the river and the material pumped suitable for construction. It also requires timber obstructions to prevent the material from flowing off, and insures the erection of but a small portion of the base of the levee.

The New Era graders used on the levee board loop just above Greenville during the past season proved unsatisfactory, partly because of the very wet weather and partly the very tough, lumpy material handled. From two to three graders were used, each requiring 16 mules and 3 men. Seven wagons were used per grader, each wagon holding a little over a yard of earth. One driver was required for each wagon. A foreman and two or three men to dress the dump were also employed. Before the contract was completed an outfit of wheel scrapers was substituted for the graders and wagons.

Mr. Andrews, levee board inspector, estimates that the graders moved about 400 cubic yards per day.

On the St. Lawrence Power Company's water-power canal, near Massena, N. Y., which was under construction in 1898, the New Era and Western graders averaged 600 to 800 cubic yards per ten-hour day.

A scraper well adapted to levee construction was also used on that work, and is described in Engineering News, December 15, 1898. It averaged 24 cubic yards per hour. The capacity of pan or bucket was 3 cubic yards. The engine was 12½ by 15 feet, and the span of the cable way between the supporting towers was 720 feet.

* * * * * * *

As before stated, with the increase in height of levee the introduction of modern excavating and conveying machinery, such as was used on the Chicago drainage canal, and is now employed in other parts of the country, is to be expected in the near future. Contractors are at the present time figuring on cheaper methods. The steam shovel, cantilever, inclined conveyor, swinging and revolving derrick, cable conveyor, steam scraper, endless-chain scraper and conveyor can all possibly be used to advantage

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in levee construction where the material moved per station and the magnitude of the contract will warrant their adoption.

New levees required.—The new work that will probably be required, owing to the caving of the bank, is as follows:

	Cubic yards.
Riverton Loop, with banquettes, stations 1590–1650 (400 L.)	215,000
Baleshed Loop, without banquettes, stations 3135–3210 (537 L.)	162,500

As before stated, it is possible that one or two short loops will be required near Jenkins Landing (433 L.), but it is hoped that low water will bring favorable changes, making them unnecessary.

Preliminary lines have been run, one east of Lake Bolivar (417 L.), leaving out Catfish Point, and one east of Five Mile Lake, leaving out Arcadia (558 L.), and thirty or more valuable plantations in the lower end of Issaquena County.

The land thrown out would be approximately 22 and 30 square miles, and the yardage in the new lines 2,000,000 and 1,500,000, respectively. There is no immediate need for these lines, and changes in the river may make their adoption entirely unnecessary for some years to come, but with a continuation of the present and past action of the river in the vicinity of the Lake Bolivar crossing, Station 3200 (434 L.) and south, and in the Fitlers to Shiloh and Albemarle to Chotard reaches, these short lines seem to be the only ultimate solution of the problem.

Your project for the expenditure of the $247,000 allotted by the commission for levees in this district for the season of 1899–1900 is in accordance with your statement, as follows:

Below Greenville.

Stations.	Kind of work.	Cubic yards.	Price.	Cost.
811–900	Banquette	73,000	$0.14	$10,220
2108–3135	Enlargement	818,000	.16	130,880
3135–3200	New levee	163,000	.12	19,560
3210–5220	Topping	147,360	.25	36,840
				197,500
	Reserved for engineering, repairs, etc.			49,500
				247,000

About 15,000 yards will have to be added to the above for topping on the Eagle Lake line.

No work by the Government above Greenville is contemplated, the expectation being that the levee board will be able to construct the Riverton Loop and such topping and enlargement as may be necessary to bring the line to a grade 3 feet above 1897 water, and construct such banquets as are essential, as follows:

Stations.	Kind of work.	Cubic yards.	Price.	Cost.
0–100	Banquette	40,000	$0.15	$6,000.00
1340–1460	....do	30,000	.10	3,000.00
1810–1830	....do	10,000	.10	1,000.00
1870–1980	....do	25,000	.10	2,500.00
1590–1650	Riverton Loop	215,000	.14	30,100.00
2092–2612	Topping, 0.5 to 1.5 feet	28,390	.25	7,097.50
2880–2900	Topping, 0.5 foot	240	.25	60.00
3930–4178	Topping, 0.5 to 2 feet	27,334	.25	6,833.50
				56,591.00

Other banquettes should be added, if within the means of the board. If this levee is enlarged instead of being topped, the approximate estimate will be as follows:

From Station 0 to Riverton Loop, inclusive, as above	$42,600.00
Enlargement, Stations 2092–2612.....250,000 cubic yards.	
Enlargement, Stations 2880–2900.....5,000 cubic yards.	
Enlargement, Stations 3930–4168.....144,000 cubic yards.	
399,000 cubic yards, at 17 cents ..	67,890.00
	110,490.00

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Extensive topping has been done by the levee board below Greenville, as shown in the record of their work; also considerable repairs and dike construction. The topping is generally not over 2 feet above the 1897 water. In accordance with your project nearly all this topping, from Station 3210 to the lower end of the Eagle Lake line, will be covered by Government topping to the 3-foot grade with 4-foot crown.

The total expenditures by the levee board during the year ending May 1 is given by the assistant engineer, Mr. Somerville, as follows:

Levee construction, including topping, not including retained percentage	$108,718.23
High-water expense, including short loop, Albemarle	5,811.53
Right of way condemnation, etc	63,218.28
Total	177,748.04

REPAIRS AND TOPPING.

Repairs to wave wash were made in the district above Greenville, and a small amount of topping done by day force below Greenville. All other work is recorded in the table of construction accompanying this report. Wave-wash repairs were necessitated by the cutting of the river slope of the new enlargement during the high water of 1898, and also at some points by the rain wash on both sides. The following table gives the cost of these repairs, etc.:

Above Greenville.

Stations.	Kind of work.	Price team per day.	Yards.	Total cost.	Yards per team.	Cost per yard.	Contractor.
						Cents.	
249–291	Wavewash	$4.49	4,920	$1,091.07	20.3	22.2	H. F. Watkins.
350–419	do	3.95	9,920	2,085.60	19.4	21	P. F. Lamb.
3036–3046	do	4.25	2,133	637.50	14.2	29.9	Hugh Morgan.
3100–3114	do						

Twenty-four stations were sodded at a cost of $13.75, or about 57 cents per station.

Below Greenville.

Stations.	Kind of work.	Price team per day.	Yards.	Total cost.	Yards per barrow.	Cost per yard.	Remarks.
						Cents.	
837–862	Topping	Wheelbarrows.	3,250	$891.56	7	27.4	Government force to be deducted from contract.
885–889	Filling holes						
890	Topping						

This includes freight bills and all expense.

This latter work is included in the statement of construction on regular contracts.

WEED CUTTING.

The weed cutting during the year above Greenville was done by Government force and below Greenville by contract. That above Greenville was cut partly on one side only, owing to enlargement contracts under construction, and part on both sides. Some new work required no cutting.

On the entire line, from Stations 0 to 4618, 4,267 stations were cut, at a cost of $1,468.10, or 34.4 cents per station.

Below Greenville a contract was made and the weeds cut from Stations 2108 to 5200 (2,748.31 stations), some stations being omitted, as above, for 30 cents per station, or total expenditure of $824.50.

In maintaining the levee, weed cutting is very essential, as it induces a good growth of grass, which adds greatly to the strength of the slope. Below Greenville, on the enlargement under contract in 1898, the contractors were required to cut the weeds and sod on the back slope, thus doing away with the necessity of clearing that portion of the line.

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HIGH WATER 1899.

The high water of the present year came mainly from the Ohio and its tributaries, the Upper Mississippi, Missouri, Arkansas, and White contributing very little. It was generally more than 3 feet below the highest water and of short duration in this district. At Cairo it remained near the crest for about sixteen days, and reached a stage of 46.2. The only high-water work necessary was sacking to prevent wave wash, the maintenance of sack and brush revetment at end of dikes, general watching, and the construction of two small protection levees, one by the Government and one by the levee board.

The levee board paid for all high-water labor except on the protection loop at Shiloh Landing, the Government furnishing the materials, sacks, lumber, etc. Where the Government had inspectors and rodmen employed they superintended the high-water operations.

The district was divided as follows:

Coahoma County line to Entaw, under supervision of levee board.

Entaw to Greenville, under supervision of Government; J. D. Van Meter, inspector.

Greenville to Station 2300, under supervision of Government; A. M. Todd and J. S. Allen, inspectors.

Stations 2300 to 3980, Fitlers, under supervision of levee board.

Station 3980, Fitlers, to Station 4400, Arcadia, under supervision of Government; G. G. Smith, inspector.

Stations 4400 to 5400, under supervision of levee board.

With the exception of the Longwood front, where the front slope of the levee was very steep, on the levee under Government supervision practically no high-water work proper was done and little or no material, sacks, etc., used.

The accompanying table gives the materials used and the cost of high-water work obtained from the levee board officials.

The revetment at end of dikes above Greenville, placed by the levee board, though not subjected to a great current, as would have been the case with the water 3 feet higher, proved very substantial and effective. They were constructed in the usual manner of a layer of brush covered with sacks filled with earth.

As the new loops at Hays Landing and Albemarle (the latter under construction by the levee board) had not been completed before the high-water season, it became necessary to construct temporary ones, on which to fight a high water if one came. Two were put up, one by the Government just above Shiloh and one by the levee board at Albemarle. These were completed before the water came over the bank.

The caving continued at Shiloh during high water, threatening the line below the protection loop constructed before the rise, necessitating an extension of the first loop. A sketch[1] showing the bank line before active caving began and at the present time accompanies this report. The conditions were very unfavorable; the water against the front levee and a pond of seep water behind.

The first temporary loop was completed about March 25 and from that date until April 13 the caving was not alarming; indeed, rather the reverse, insuring, I thought, the permanence of the front line during the high water.

April 13, however, the caving became very active, and as the center of the front levee was but about 300 feet distant at the nearest point and the bank caving from 25 to 30 feet in a day I deemed it advisable to construct another loop, in spite of the great difficulty, and obtained your approval for the same.

April 14, Mr. Robert Johnsen's (subcontractor) force of teams was employed at $4 per day including all labor and work commenced with 51 teams. Thirty-five drag scrapers were used at first, but afterwards they were given up and wheel scrapers employed, dry material being carried from the old levee on to the new. An average of 84 teams and over 161 wheelbarrow men were used per day. The entire number of laborers being about 300 per day and the levee containing about 17,900 cubic yards, practically finished April 22. A levee of small section on which a high-water fight could have been made was up at 10 o'clock on the night of the 19th, or five days after beginning active operations. This was raised and enlarged to a section between 9 and 10 feet in height, with about 7-foot crown and slopes averaging about 2½ to 1. In course of construction much ditching had to be resorted to in order to drain off the seep water. The planters in the neighborhood cooperated promptly at my request by requiring their farm hands to man the wheelbarrows, and their managers to act as foremen. Permission was obtained from the governor by Mr. L. C. Dulaney to use the convicts employed on Dulaney's plantation in the emergency. Seventy-five men were procured. The convict force was paid by the levee board.

A quarter boat and two barges were used and about 60 laborers from Greenville employed in addition to the others mentioned. The laborers subsisted were paid $1 per day; those subsisting themselves, $1.25. Subsistence cost 23.4 cents raw and 31.6 cents served.

[1] Omitted.

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The farm laborers and their bosses did remarkably faithful and efficient work. The convicts made a much poorer showing.

The following statement gives the details of the work, cost, etc. Inspector G. G. Smith, and his assistants, C. J. Coney, George Stephany, and M. J. Pilcher deserve special commendation for their untiring energy and faithfulness day and night in conducting these high-water operations under the most trying and difficult conditions, with unorganized and unskilled labor:

Statement showing cost of high-water protection loop at Shiloh Landing, Miss., April, 1899.

Team hire paid Robert Johnsen		$3,328.00
Team hire paid Shippey & Kilpatrick		36.00
Pay rolls, including all labor, etc		2,145.76
Cost of subsistence on quarter boat		225.61
Cost of supplies on quarter boat		22.29
Lumber received, 34,188 feet B. M., worth	$458.89	
Lumber returned, 33,228 feet B. M., worth	445.93	
Lumber used		12.96
Cost of towing		223.70
Total		5,994.32

Contents of levee, 17,901 cubic yards; cost per yard, not including convict force, 30 cents.

The convict force furnished by the levee board that worked amounted to 164 days' labor, which should not cost over $400. Bills for the latter have not yet been submitted to the levee board.

Details of cost of team and barrow work, not including subsistence, transportation or other expenses, are as follows:

Team work.

Per cent of work done	53
Total yards moved by teams	9,545
Total number of teams	841
Total cost of teams, at $4	$3,364
Cubic yards per team	11.34
Cost per yard, cents	35.24

This includes all teams on work; those handling brush, barrows, planks, etc.

Wheelbarrow work.

[Including convicts.]

Per cent of work done	47
Total yards moved by barrows	8,356
Total number of barrows	1,292
Total cost of barrows at $1.25	$1,615
Cubic yards per barrow	6.46
Cost per yard, cents	19.33
Convicts—	
Total yards moved by convicts	1,386
Total number of convicts	300
Cubic yards per convict	4.62

SEEPAGE OBSERVATIONS.

Before the high water subsided the levee was examined carefully throughout the entire district for the purpose of observing the effect of the water on the material of the levee proper and the land directly behind it, with the result shown in the accompanying table.[1] It may be briefly stated that the water was too low and of too short duration to produce much effect on the embankment or the foundation. Generally speaking, there was no seepage on the back of the levee, but the ground was saturated in most places, as it generally is, for distances varying with the local conditions, material, drainage, etc. The information gained can be of little value in determining what the section will be subjected to in a really high water and what the effect will be.

It has been suggested that the specifications be modified so that contractors would be compensated for all ditching at the cost per yard bid on the embankment; this

[1] Omitted.

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I think is very desirable. The engineer should have the authority to require the contractor to cut such ditches as he deemed necessary, paying him as stated. Under the present regulation much trouble is experienced by the contractors refusing to do necessary drainage because of the extra cost that they had not calculated on in submitting bids.

I desire to reiterate what I have urged in other reports, i. e., the prevention of damage done by using the top of the levee as a road. The recent survey above Greenville shows numerous places where the crown has been cut down over a foot in a short time, at one place by hauling logs on the levee, and at others by riding and driving on it.

Lines of posts have been placed across the levee by the Government during the year at intervals of about a half a mile, and the levee board officials have promised to have those driving on the levee arrested and prosecuted, all to no effect. The posts in many places are cut off or pulled up, and the people using the levee as a roadway are not prosecuted. Refusal by the Government to spend money in the construction of levees unless their maintenance unimpaired by wagon travel is guaranteed would probably cure this evil.

The money expended during the year is shown in the accompanying statement.[1] The totals are as follows:

	Cost.	Per cent.
Cost of construction	$354,245.10	89
Maintenance and repairs	19,974 39	5
Engineering, inspection, etc	23,984.63	6
Total cost	398,204.12	

This includes $743.90, charged to the district by Mr. Hider for steamboat inspection trips during the year.

New repairs.—The loss to new levees by wave wash and preventing the growth of sod during the high water will be replaced by the contractor or hired force during the coming season. It is impossible to state the exact extent of this work until the water falls farther.

Survey of levee above Greenville.—The levee from the Coahoma County line has been remeasured in the last two months and iron stakes and red stakes set. All benches have been tested and elevations of iron stakes and top of levee obtained.

Also, cross sections every 500 feet have been noted and notes of topography and drainage secured for use in estimating future enlargement and new work. The total cost of the work was as follows:

Survey, stations .0 to 4285 above Greenville.

Party February 20 to April 24, pay roll	$408.69
Team	185.00
Traveling expenses of recorder and rodman	122.95
Cost of new iron bench marks	96.00
Freight bills on team, etc	7.50
Total	821.14

Owing to the high water it was impossible to measure some of the sections on the river side. These measurements will be made at a probable additional cost of about $130, making the total cost about $950.

The levee measured was 81 miles in length, making the cost per mile to date about $10. More than 60 per cent of this cost was chargeable to locating the iron benches, etc., and the delay caused by their placing.

From the notes obtained on this survey a profile is being made which will show all information pertaining to the levee at the present time.

A map, giving new enumeration, will be submitted as soon as the profile is completed.

This report is accompanied by the following statements and drawings:

Statement of details of construction during the year.
Statement of seepage during high water.[1]
Statement of expenditures.[1]
Statement of rainfall.

[1] Omitted.

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Statement of levee board construction and expenditures.
Map showing backwater at lower end of district.[1]
Map showing change in bank line at Shiloh.[1]
Profile of high-water grade.[1]
Drawing of hoisting machine used at Longwood.[1]

In accordance with your verbal instructions the map of the district showing the changes in alignment, new lines, etc., is omitted.

Yours, respectfully,

H. ST. L. COPPÉE,
Assistant Engineer.

Capt. H. C. NEWCOMER,
Corps of Engineers, U. S. A.

Rainfall at Greenville, Miss., from January, 1886, to April, 1899, inclusive.

	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	7.30	3.62	6.11	4.89	4.98	3.79	5.59	4.63
February	5.51	4.41	2.41	2.71	6.30	8.38	3.60	5.27
March	5.59	2.74	9.88	1.85	6.63	4.43	3.91	2.70
April	4.76	1.99	1.65	2.60	11.01	2.24	9.74	5.69
May	1.20	3.13	4.54	4.03	4.67	3.43	2.93	7.39
June	4.81	4.28	3.95	7.09	2.31	3.02	2.54	6.59
July	2.89	5.62	2.28	4.50	2.28	12.32	9.25	2.33
August	2.99	2.20	10.39	1.86	2.09	2.44	3.50	2.87
September	2.93	3.61	2.69	4.05	4.94	1.54	6.96	2.67
October	2.31	3.76	1.61	.40	2.79	.86	.80	.34
November	6.89	.97	3.89	5.92	1.48	5.40	2.44	6.34
December	2.97	6.04	3.89	1.05	3.94	3.40	6.54	1.87
Total	50.15	42.37	53.29	40.95	53.37	51.24	57.80	48.69

	1894.	1895.	1896.	1897.	Mean 12 years.	1898.	1899.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	7.23	6.33	2.59	4.50	5.13	8.38	5.38
February	3.18	1.25	4.93	4.21	4.35	3.05	4.41
March	8.98	7.37	7.77	11.37	6.10	3.13	5.44
April	4.08	1.70	2.30	1.97	4.14	4.18	2.24
May	.57	1.38	.92	6.19	3.36	3.28	.....
June	.33	11.28	.92	1.09	4.02	2.40	.....
July	5.15	4.61	1.25	4.43	4.74	1.69	.....
August	5.38	6.02	1.44	2.72	3.66	7.95	.....
September	1.77	.32	.71	.02	2.68	5.75	.....
October	1.36	1.32	2.89	1.75	1.68	6.03	.....
November	.34	3.72	5.63	3.67	3.89	4.68	.....
December	4.24	3.57	.29	9.12	3.91	1.49	.....
Total	42.61	48.87	31.64	51.04	47.66	52.01	.....

[1] Omitted.

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Levee work in Lower Yazoo Levee district, May 1, 1898, to May 1, 1899.

[E.=Enlargement; B.=Banquette; N.=New.

Stations.	Miles below Cairo.	Contractor.	Cubic yards in contract.	Cubic yards placed during year.	Total laborers.	Total teams.	Total scrapers.	Yards per teamster.	Yards per scraper.	Price per cubic yard.	Average height.	Average haul.	Kind of work.
										Cents.	Ft.	Ft.	
300- 400	372 L.	Ernest Hyner	117,207	35,552	2,301	2,639	1,177	13	30	13	14.1	300	E.
500- 600	376 L.	E. B. Mantle	121,980	31,112	1,951	1,279	868	24	36	12	13.9	240	E. & B.
900- 993	379 L.	J. C. Neely	20,986	20,986	1,022	735	524	29	40	8.85	3.5	200	B.
1037-1058	392 L.	Hugh Morgan	4,660	4,660	174	121	78	39	60	9.5	3.5	150	B.
1037-1200	392 L.	Stone & Stansell	165,695	82,261	4,441	3,097	2,214	27	37	15.48	16.8	175	E.
1202-1235	394 L.	Hugh Morgan	8,530	8,530	385	250	156	34	55	9.5	4.5	135	B.
1491-1530	399 L.	T. Sullivan & Co	13,194	13,194	684	501	352	26	38	8.95	4	135	B.
1870-1980	403 L.	do	27,848	27,848	1,538	1,079	725	26	38	8.95	8	160	B.
2005-2066	404 L.	Robert Johnsen	17,920	17,920	803	555	368	32	49	8.74	4.7	140	B.
2700-2800	419 L.	McCadden & Roach	135,000	80,660	4,774	3,228	2,375	25	34	12.23	16.6	175	E.
2800-2880	420 L.	Ernest Hyner	90,955	90,955	4,873	3,563	2,520	26	36	12	17	175	E.
3000-3100	431 L.	do	104,052	87,081	4,929	3,446	2,276	25	38	12	16.2	150	E.
3100-3187	433 L.	do	92,023	28,257	1,624	1,217	908	23	31	16	17.6	160	E.
3166-3186	433 L.	T. Sullivan	10,306	10,306	540	393	230	26	45	12	7.5	140	B.
3306-3329	436 L.	Jas. H. Cary	80,032	13,670	738	558	395	25	35	12.5	15	150	N.
3329-3360	436 L.	McIntyre & Howard	155,235	122,447	6,237	4,606	3,149	27	39	12.98	18	170	N.
3360-3400	436 L.	P. F. Lamb	156,565	82,380	4,561	3,332	2,243	25	37	13.5	15.5	155	N.
3400-3440	436 L.	McLeod & McCarten	158,176	29,816	1,772	1,289	834	23	36	12.7	15.8	160	N.
3469-3514	436 L.	do	165,644	43,906	2,119	1,594	1,082	28	41	12.7	15	155	N.
3880-3930	445 L.	Arnold & De Garis	43,683	8,252	860	550	345	15	24	16.1	16.4	180	E.
4150-4200	459 L.	do	46,692	27,083	2,181	1,285	826	21	33	15.75	19.4	180	E.
4200-4300	460 L.	Ben Talley	193,120	121,903	5,765	4,087	2,668	30	46	13.95	15.6	180	E. & N.
4300-4400	475 L.	McCadden & Roach	142,762	62,105	3,294	2,340	1,539	27	40	13.4	14.6	250	E. & N.
4400-4500	476 L.	Timothy Sullivan	110,503	79,845	4,086	3,030	1,980	26	40	12.95	14.6	250	E.
0-60	479 L.	do	57,282	6,115	1,047	649	511	10	12	10.75	14.8	500	E.
9-100	479 L.	C. A. Winter	26,155	2,231	280	158	101	14	22	9.95	5.3	140	B.
60-100	479 L.	L. C. Dulaney	39,776	38,658	2,190	1,313	909	29	43	10.23	14.9	100	E.
100-150	480 L.	T. Mike	41,125	38,375	1,764	1,086	715	35	53	9.74	14.7	100	E.
150-200	481 L.	do	44,124	30,619	1,374	888	574	35	53	9.45	15.1	100	E.
100-200	480 L.	John G. Sessions	26,890	10,927	460	312	223	35	49	9.98	5	140	B.
200-300	483 L.	H. F. Watkins	66,000	46,981	1,858	1,225	831	38	57	10	10.7	180	E.
300-400	485 L.	John G. Sessions	56,070	56,070	2,239	1,400	934	40	60	10.50	9.9	120	E.
400-500	487 L.	J. H. McTighe	60,000	43,310	1,813	918	605	47	72	12.50	9.4	150	E.
500-600	489 L.	T. Mike	58,108	58,029	2,331	1,309	864	44	67	8.74	10.4	175	E.
600-700	491 L.	C. A. Winter	64,782	64,782	4,662	2,440	1,711	27	38	13.875	10.8	180	E.
700-790	492 L.	do	65,000	44,124	2,619	1,447	1,025	31	43	13.375	13.2	150	E.
811-900	492 L.	John C. McIntyre	106,000	43,786	4,927	1,692	1,109	a 24	37	16.625	17.2	200	E.
900-1000	493 L.	J. B. Lewis	112,000	98,641	4,676	3,007	2,180	33	45	13.25	16.4	200	E.
1000-1100	494 L.	do	99,000	59,256	2,911	2,206	1,517	27	39	11.9	15.3	200	E.
1070-1130	495 L.	J. F. Kerr	26,208	26,208	1,115	839	521	31	50	11.5	7.3	200	B.
1100-1200	495 L.	T. Mike	84,000	43,053	1,879	1,399	968	31	44	9.5	14.7	175	E.
1200-1300	497 L.	do	76,000	27,409	1,278	844	577	32	48	9.99	12.8	175	E. & N.
1300-1400	499 L.	Robert Johnsen	92,830	57,546	3,907	2,552	1,722	23	33	14	17	250	E.
1400-1500	500 L.	M. McTighe	132,809	88,247	6,802	3,953	2,932	b 21	28	18	18.1	350	E.
1500-1600	502 L.	Jno. C. McIntyre	91,700	62,961	3,970	2,490	1,803	25	35	15.375	16.7	200	E.
1600-1700	503 L.	Ben Talley	75,000	30,117	1,860	1,049	721	29	42	14	15.8	225	E.
1700-1800	504 L.	H. F. Watkins	58,000	17,500	1,138	768	555	23	31	11.48	13.1	200	E.
1800-1900	505 L.	J. & A. Wynn	71,000	63,952	2,881	2,040	1,469	31	44	10	12.8	200	E.
1900-2000	512 L.	Martin Jennings & Co.	47,812	47,812	2,120	1,538	1,083	31	44	11.875	11.4	200	E.
2000-2060	513 L.	Chas. T. Worthington.	111,951	111,951	6,673	4,793	3,376	23	33	9.875	11.4	125	N.
2060-2110	514 L.	Ben Talley	100,175	100,175	4,221	2,965	2,060	34	49	10	12.5	125	N.
2400-2571	527 L.	J. E. Kerr	29,250	29,250	1,633	912	573	32	51	14	4.5	140	B.
3167-3184	537 L.	Robert Johnsen	26,120	26,120	1,425	986	659	26	40	15.70	12.5	225	N.
4078-4133	554 L.	Shippey & Kilpatrick.	164,000	94,382	6,140	3,941	2,376	24	40	14.74	13.8	190	N.
4133-4188	555 L.	do	208,155	97,321	7,557	3,268	1,950	c 29	50	14.74	12.7	175	N.
4188-4243*a*	555 L.	do	84,774	61,366	2,938	1,800	1,245	d 34	49	14.74	10	160	N.

a 467 wheelbarrows; average, 7 cubic yards.
b 6,901 cubic yards moved by machine and cars.
c 12,469 cubic yards moved by wheelbarrows.
d 992 cubic yards moved by wheelbarrows.

Respectfully submitted.

H. ST. L. COPPÉE, *Assistant Engineer.*

GREENVILLE, MISS., *May 1, 1899.*

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Table showing levee construction by the Mississippi State levee board May 1, 1898, to May 1, 1899.

Stations.	Miles below Cairo.	Cubic yards in contract.	Cubic yards in place.	Price per cubic yard.	Team price per day.	Extras paid.	Total expended.
				Cents.			
500	376 L.	3,930	3,930	.....	$4.00	.....	$522.45
1585	400 L.	22,313	22,313	14	.....	$12.00	3,135.82
1870–1900	403 L.	.....	5,169	11.5	.....	.....	595.27
2066–2200	405 L.	82,260	19,295	14.3	.....	.....	2,345.30
2942	431 L.	25,495	25,495	17	.....	.....	4,334.15
3501–3503	436 L.	1,817	1,817	.....	4.00	.....	363.40
4485–4545	478 L.	200,004	200,004	13.44	.....	.....	26,880.53
4574–4581	479 L.	31,000	28,484	21.97	.....	188.75	5,479.68
4591–4617							
4581–4591	479 L.	13,811	13,811	9.4	.....	393.19	1,298.23
2102–2150	514 L.	3,700	3,700	.....	4.00	.....	936.00
2735–2742							
2794–2813	530 L.	4,520	4,520	.....	4.00	.....	1,530.00
2873–2901							
3000–3500	535 L.	25,150	25,150	.....	4.00	.....	11,324.00
3500–3550	545 L.	25,000	4,166	13.5	.....	.....	478.05
4750–4890	567 L.	131,850	26,312	12	.....	.....	2,683.82
		156,535	85,686	15	.....	.....	10,924.97
		161,349	124,396	15.4	.....	.....	16,274.40
Protection loop at Albemarle	.....	76,713	76,713	.....	4.00	.....	19,118.22
Total	.....	.....	670,961	.....	.....	593.94	108,124.29

High-water expenditures.

Labor, material, etc	$3,943.88
Topping stations 3700–4000	1,008.00
Topping stations 4250–4350	390.00
Extension of protection loop at Albemarle	459.65
Total	5,801.53

Respectfully submitted.

H. ST. L. COPPÉE, *Assistant Engineer.*

GREENVILLE, MISS., *May 1, 1899.*

REPORT OF MR. E. C. TOLLINGER, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 1, 1899.*

CAPTAIN: I have the honor to submit the following report of operations in the Upper Tensas Levee district, from May 1, 1898, to May 1, 1899:

In accordance with instructions contained in your circular letter of August 10, 1898, I relieved Assistant Engineer W. S. Brown of the Upper Tensas Levee district in Louisiana September 1, 1898, thereby assuming charge of the entire district. This reorganization was believed to be more efficient and economical for the administration of the public service.

This report covers the Tensas Basin in Louisiana for the period from the annual report of May 1, 1898, to September 1, 1898, under the direction of W. S. Brown, assistant engineer.

UPPER TENSAS LEVEE DISTRICT (402 TO 606 MILES BELOW CAIRO).

This district extends from Red Fork, on the Arkansas River, to a point in Louisiana opposite Warrenton, Miss. There is a continuous line about 172.2 miles long, extending from Costello's gin, on Amos Bayou, along that bayou and Cypress Creek to the Mississippi River (13 miles), and thence along that river to the lower end of the district (159.2 miles).

The district is partially protected from overflow from the Arkansas River by a levee running along that river from near Pine Bluff to the foot of Lake Jefferson. From Pine Bluff to Red Fork the line is of comparatively weak section, built and maintained by local authorities and railroad interests. From Red Fork to the foot of Lake Jefferson (12.4 miles) the line was built in 1894–1896 by the United States with the standard section of 8-foot crown and slopes of 1 on 3, without banquette.

The total yardage in this district May 1, 1898, was about 24,042,150 cubic yards the United States having built about 16,800,197 cubic yards.

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During the past year there has been added to the line about 1,456,590 cubic yards, paid for by the United States, and about 617,082 cubic yards paid for by the Tensas Basin and Fifth Louisiana districts and State of Louisiana.

The length of line thrown out by the construction of the new loops was about 9,400 feet, containing about 236,059 cubic yards.

Tabulated statements of expenditures and work done by the United States accompany this report.

At the close of the annual report of 1898 the following work was under contract for construction, the established grade being 3 feet above the high water of 1897:

In Arkansas:
Stations 180–230, 425 R. (complete).
Stations 420–484, 427 R. (incomplete).
Stations 630–660, 430 R. (incomplete).
Stations 1080–1200, 441 R. (incomplete).
Stations 1490–1510, 449 R. (complete).
Stations 1740–1780, 452 R. (complete).
Stations 1810–1941, 466 R. (incomplete).
Stations 3160–3185, 496 R. (incomplete).

In Louisiana:
Stations 0–256, 520 R. (complete.)
Stations 3428–3550, 583 R. (incomplete).
Stations 4432–4452, 603 R. (complete).
Stations 4452–4472, 603 R. (complete).
Stations 4472–4492, 604 R. (complete).
Stations 4492–4507, 604 R. (complete).
Stations 4540–4551, 605 R. (complete).

Stations 1810–1941 (466 R.).—This work was poorly managed from the beginning, the contractor grossly failing to comply with the terms of the contract. The work was relet to Mr. Ben Talley at 22 cents per cubic yard, being an advance of 6 cents per cubic yard on the contract price, thus taking up about the retained percentage. The repeated heavy rains and rising river made it necessary for Mr. Talley to suspend work in February, 1899.

Contracts Stations 4432–4452, 4452–4472, 4472–4492, and 4492 to 4507 closing Biggs Crevasse, have all been completed.

The records of the Weather Bureau at this station (Greenville) give an excessive number of rainy days, which were generally distributed throughout the fiscal year. The mean rainfall in August was 7.9 inches, and from that time on till March was never less than 4½ inches, except in December. The number of actual rainy days being 100, add to this 75 days to cover time lost waiting for work to dry out sufficiently to resume operations, which will give nearly half the year as being lost. This shows a condition which is almost unprecedented in the history of levee building, and together with the time lost by quarantine in the early fall of 1898, was the cause of contractors, almost without exception, being behind in closing up their work, and in the majority of instances losing money. Ample credit should be given to nearly every contractor in the district for excessive effort in the way of drainage and other work necessary to overcome the conditions, which efforts were in many instances of no avail. This extra effort and expense on the part of the contractors had led to a number of the contracts being extended from time to time. An exaction of the completion of the work within the time first set would have been ruinous to them, and in the nature of demanding what was nearly, if not entirely, impossible.

The contracts from Stations 4507 to 4540 and 4551 to 4570 (Louisiana), which were awarded to the J. S. McTighe B. C. & I. I. Co., have had no work done on them by the contractors owing to the fact that nearly the whole time since the letting the surface has been thoroughly saturated and the deep and wide borrow pits filled with water. The contract time has expired on this work. The work from Stations 4551 to 4570 has since been topped to a grade 3 feet above high water of 1897 by J. T. McClellan under informal contract with the United States. Contract Stations 4507–4540 was partially topped. This work was done under adverse conditions, and as the river had been stationary with favorable conditions for an early fall it was suspended on April 22.

On the contract of Arnold, DeGaris & Co. Stations 4540–4551 (605 R.), part of the levee slope during high water of 1898 slid partly away from the crown on each side. This happened at the maximum rise of 1898, and as a sudden decline set in work was suspended, and after being allowed to dry out work was recommenced just prior to high water of 1899, and the levee finished up to about net grade. The same section then slid out as before. Following this, permission was asked to relieve the contractor of this work. This has been done with your consent. I am satisfied that the work can be made to stand if done during a dry season and ample time allowed for the work to settle before another high water, without greater expense than the original contract price.

Bids opened July 6, 1898.

In Arkansas:
Stations 1780–1810, 466 R. (incomplete).
Stations 1942–2047, 468 R. (incomplete).
Stations 3400–3500, 505 R. (incomplete).
Stations 3500–3600, 506 R. (incomplete).
Stations 3600–3700, 508 R. (incomplete).

In Louisiana:
Stations 2411–2500, 562 R. (incomplete).
Stations 2810–2931, 574 R. (incomplete).
Stations 2931–3031, 576 R. (incomplete).

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Bids opened August 12, 1898.

In Arkansas:
Stations 34– 43, 426 R. (complete).
Stations 520– 605, 429 R. (incomplete).
Stations 605– 630, 430 R. (incomplete).
Stations 710– 750, 432 R. (complete).
Stations 1200–1240, 442 R. (incomplete).
Stations 1730–1740, 451 R. (complete).
Stations 2740–2850, 490 R. (incomplete).
Stations 2850–3065, 494 R. (complete).
Stations 3185–3400, 496 R. (complete).
Stations 3700–3760, 509 R. (complete).
Stations 3100–3160, 494 R. (incomplete).

In Louisana:
Stations 2500–2601, 564 R. (incomplete).
Stations 3031–3118, 577 R. (incomplete).
Stations 3118–3197, 597 R. (incomplete).
Stations 3197–3277, 580 R. (incomplete).
Stations 3277–3310, 579 R. (complete).
Stations 3310–3328, 582 R. (incomplete)

The incomplete work on the above contracts was topped by the contractor or at his expense by the Government in advance of the high water.

The following bids were opened on the respective dates given below:

In Arkansas.
Stations 150–214, 405 R. (complete), October 15, 1898.
Stations 680–710, 431 R. (complete), November 11, 1898.
Stations 906–931, 438 R. (incomplete), November 9, 1898.
Stations 1240–1490, 444 R. (complete), October 15, 1898.
Stations 1826–1831, 466 R. (complete), August 26, 1898.
Stations 655–688, Red Fork extension (not begun), January 16, 1899.

Stations 906–931 (438 R.).—The only obtainable earth, except at prohibitory cost, is on river side of the levee. The bank at this point is very low and earth can not be had unless the river is below the one-half stage. This work will be completed in the late fall, the contracts having been extended. This work is being paid for jointly by the United States, the Desha Levee board, and the Tensas Basin Levee board.

Red Fork extension.—At a joint meeting of the Red Fork, Desha, Chicot, and Tensas Levee boards, they set aside and placed to your order the sum of $11,000 for the extension of the Arkansas River Levee from station 655 to station 588.

Of this sum the Desha County board paid one-eleventh, the Red Fork board two-elevenths, the Chicot county board three-elevenths, and the Tensas Basin board five elevenths.

High water of 1899.—The high water of this season was not of a sufficient magnitude to cause anxiety at any point along the entire line. Very little expense was incurred on its account, and that only as a precautionary measure in case of danger increasing to any great extent. The greater part of the expense incurred was on Reed Levee and was borne by the Fifth Louisiana Levee district.

The United States Government furnished quarter boats and barges to quarter the labor and transport material. The quarter boats were used, but the barges were not.

The maximum gauge readings are give for 1897, 1898, and 1899.

	1897.	1898.	1899.
Cairo	51.62	49.78	46.2
Helena	51.75	49.11	46.8
Arkansas City	51.9	51.13	48.6
Greenville	46.75	46.15	43
Lake Providence	44.54	44.35	41.7
Vicksburg	52.48	49.4	47.3

There is always a more or less uncertain feeling of anxiety when the river has reached a fairly full stage from Pittsburg to Vicksburg. It being usually the breaking up of the winter season, and the probability of heavy rains over the entire country drained by its tributaries, makes it incumbent upon those who have the levees in hand to provide for an emergency even before it is imminent. This, when done before actual danger is at hand, when compared with the cost of emergency work with the flood high up on the levees, is very moderate. To defer such expenditures would be entirely contrary to sound practice.

Fortunately these emergency expenditures were very light in the Upper Tensas Levee district this season, and were paid for by local boards in most instances.

Seepage.—In accordance with instructions contained in your letter of April 1, I have caused observations to be made to determine when it appears in the back slope of the levee and in the natural surface beyond. The seepy stations are tabulated.

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The distance from the levee ranged from a few feet to 3,000 feet. Such observations are very unsatisfactory, and the information acquired is not applicable to any purpose except in the immediate locality. Seep water has been known to make its appearance on the top of knolls, or ridges, and the low ground immediately around to remain perfectly dry. The amount of seep water and the distance that it may appear depends on the hydrostatic pressure and on the composition and formation of the substrata. While the seepage has been very general, it has been confined nearly entirely to the natural surface. In some localities the seepage was said to be worse this season than in either 1897 or 1898, though the hydrostatic pressure was much less. This is thought by some to be due to the fact that the flood carried little sediment as compared with the two previous floods, and the saturated condition of the ground from frequent rains generally distributed throughout the season. It is noticeable that a flood out of the Arkansas River, which is usually heavily charged with sediment, will not produce seepage to the extent that comparatively clean water like this season's did. The seep water this season covered nearly every foot of ground from 1 mile below Red Fork to the foot of Lake Jefferson, from the base of the levee to 3,000 feet out. There was only a moderate head of water against the levee, from 3 to 6 feet. This area had pretty generally distributed on it thousands of crayfish holes, their mud mounds appearing above the surface. While this feature is worth noting, I do not attach any special importance to it.

High-water protection.—Organization for high-water protection was begun by putting on inspectors who covered the line every day. The object of this was to detect leaks that might develop from burrowing animals or from decayed logs or roots in the old defective levees. This expense was generally borne by the local boards, the Government supplying material. The Government had authorized the use of material and tools on hand for that purpose. The plan was one of cooperation, the local boards recognizing the fact that it was best to employ men having experience and in every way well qualified for their work.

Flood area.—The area covered by the flood of 1899 is small compared with 1897 and 1898. The flood water passed between Red Fork and Amos Bayou levees at two points, the first being at Malpus Ditch, which is about 3 miles above Costello's Gin, the volume being 72 feet wide, with an average depth of 4 feet; the second point being at what is known as the Newman Slough, which is 4 miles above Costello's Gin. The volume at this point was 110 feet wide, and maximum depth 10 feet. The discharge through these two openings was carefully measured, and found to be 2,400 cubic feet per second. The water passing into Amos Bayou this year did not put it out of its banks. The low swamps flooded to some extent, but none of the cultivated land lying south of Costello's Gin was inundated. Boggy Bayou Lake, back of Arkansas City, rose about 3 feet, putting it within about 1 foot of the top of the banks.

Outlets to Boggy Bayou.—Flood water from Boggy Bayou is drained into Bayou Maçon through three channels, known as East and West Clay Bayous and the Kaleen Ditch (unfinished). The two Clay Bayous are natural sloughs, badly choked up with a thick growth of cottonwood bushes. The Kaleen Ditch is a small canal, of about 6,000 feet in length, extending from the lower end of Boggy Bayou Lake to a point in Dry Bayou, about 2 miles from where Dry Bayou empties into Bayou Maçon. So it will be observed that the water passing into Amos Bayou flows into Boggy Bayou, and from Boggy Bayou into Dry Bayou, thence into Bayou Maçon, the latter being the natural outlet for all the streams north of Bœuf River Cut-off, which is between the Mississippi River and Bayou Bartholomew. This drainage, which will cost approximately $30,000, should be undertaken at once by the local levee boards, and completed as soon as practicable.

The Arkansas River Levees.—The benefits resulting from this line will always be limited until they are either extended north up Amos Bayou from Costello's Gin and south from the foot of Lake Jefferson to the mouth of Cypress Creek, or are closed on the main line immediately below Boggy Bayou.

The weight of data collected regarding this important matter seems to favor the construction of what is known as the Dry Bayou line.

Surveys were made in 1889 to determine the cost of extending the line south to mouth of Cypress Creek, and again undertaken in 1899 to determine beyond peradventure the solution of this knotty problem; but the high water prevented this being finished. The work will be again taken up and completed.

The discharge between these lines was given in report of 1897 approximately at 120,000 cubic feet per second. This volume of water during a flood period of twenty days is sufficient to destroy in a measure any value derived from the levee system on the Arkansas and Mississippi rivers. This, it seems to me, should receive prompt attention from the Mississippi River Commission and the local levee boards. What seems to me to be a fair distribution of the funds in this matter would be for the Government to complete the system south of Red Fork and the local boards to complete the system from Red Fork to near Pine Bluff, or the head of the system.

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High-water marks.—These were taken at sufficient intervals to be used in the future if needed.

Sand boils.—The levee between Stations 3980 and 4016 crosses an arm of Willow Lake. This levee averages 20 feet in height. At Stations 3989 to 3991 many sand boils have developed. The levee at this point is 22 feet in height. These boils extend from base of levee to 800 feet out, and are from 2 inches to 18 inches across, being several hundred in number. During the flood of 1897 sufficient sand was carried out from under the base of the levee to allow the banquette to cave in. By a liberal use of sacks and brush no further harm was done during the flood. To provide against a recurrence of this the banquette was given larger dimensions, but the floods of 1898 and 1899 show that it will be necessary to use sheet piling on the river side, extending through the sand and into good natural soil, before the danger of a crevasse is averted. There are no others in the district needing attention.

Specifications.—The specifications now in use, if carried out to the letter, will give good levees.

Standard cross section.—The one adopted for a minimum for ordinary levees has a form of 8-foot crown, slopes 3 horizontal to 1 vertical, and banquette, beginning 8 feet below crown of levee, crown 20 feet, with crown slope 10 to 1, back slope 4 to 1.

This form is used in all cases except where banquette is omitted for lack of funds, in the Third district in Arkansas and Louisiana, except deep bayou crossings and where the material is of poor quality. In such cases the crown is increased, in extreme cases to 12 feet, slopes 5 to 1, but usually 10-foot crown, slopes 4 to 1, grade 1 to 2 feet above the standard section. My preference is for 3 to 1 on river side and a broken slope on the land side. The broken slope is 3 to 1 for the first 6 feet below the crown, 6 to 1 for the remaining slope to take the place of banquette, thereby increasing the base, making a better distribution of the material with reference to pressure and obviating the annoyance of travel.

Conditions exist in a few instances in which we are warranted in increasing the slopes to exceed the above, that a greater area might be covered to prevent the sinking of the foundation during construction. The crown, it seems to me, need not exceed 8 feet in any instance, provided, however, that sufficient material is put into the slopes. There has been little data collected during the high water of 1897, 1898, and 1899 to warrant any change of the present standard section, except in special cases and for a more thorough preparation of the foundation. This last adds to the first cost, but this is soon compensated for during high-water periods by a minimum high-water expenditure.

Pasturing.—It seems to me that the pasturing of the levees during the summer months, by cooperation with the local boards and planters, would prove of great advantage. This would lessen the cost of the weed cutting and give a clean levee trunk, which could be easily inspected.

Weed cutting.—It would be well, in order to keep the levee free from weeds and growth of all kinds, to advertise the weed cutting for the whole of each subdistrict, requiring the weeds to be cut twice each year, between the 1st and 15th of June and the 1st and 15th of September, and that every station be gone over carefully and the weeds and other growth removed regardless of size. Travel on levees should be prohibited at all times.

Bench marks.—Stone benches should be placed at intervals of 5,000 feet along the line of levee.

Drainage.—The high waters of 1897, 1898, and 1899 have thoroughly demonstrated the necessity for thorough drainage of the levees, by cutting seep ditches that will be sufficient to carry all seep water entirely away from the levee base.

The conditions are in the main favorable for this work, but would involve the expenditure of a considerable sum of money. This amount can only be determined by a thorough system of surveys. The benefits that this would afford the adjacent properties would be an inducement for the planters to provide the right of way, and probably share the cost of construction and maintenance.

This matter should be taken up and means devised by which the local boards could jointly undertake this work, as there is some question of the legality of using United States funds for this purpose.

I would again recommend that a section, say 20 miles of levee, be surveyed for the necessary drainage, and some means provided by which it can be put into effect. This would demonstrate the advisability of the scheme, and from this, if found practicable, an estimate can be made for the entire district.

The levees constructed to the new grade of the commission will so increase the hydrostatic pressure during an extreme flood of long duration, that the country will be inundated from seepage for nearly a mile away from the levee.

Protection from wave wash.—About 30 per cent of the line in the Upper Tensas Basin in Arkansas and Louisiana is very much exposed to wave action. It is again recommended that willows or cottonwood be planted along these exposed fronts, the cost of which would be trifling in comparison with the constant annual expenditure for planking and sacking.

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Dikes.—The dikes on the north side of Leland Neck, Station 2201, and at the angle south of Chicot, Station 750, were revetted at a small cost previous to the flood of 1899 and were of no expense during the high water. The end of the Red Fork Levee at the foot of Lake Jefferson was revetted after the water came against it on account of cutting, but was of no great cost to keep up. It is proven that the best practice is to do this work in advance of the water.

SURVEYS.

A survey was made in January on the Arkansas River for the purpose of extending the Arkansas River Levee from its present terminus at the foot of Lake Jefferson, and also to determine the practicability of closing Cypress Creek and connecting the Arkansas levees with the Mississippi River levees below that point. This will depend mainly on the disposition that can be made for drainage which has naturally been accommodated by Cypress Creek. This survey was discontinued on account of rise in the river during the latter part of the month, which overflowed all the swamp land between the two levee systems.

Shore line.—Shore lines in the caving bends have been located and the rate of caving during the last four years is as follows:

Cypress Bend (425 to 432 R.).—From a point in the head of the bend above Cypress Creek to the point below Old Chicot Landing. The maximum caving in this bend occurred about 3,000 feet above the mouth of Cypress Creek, which was about 500 feet in the last four years. There is no levee along this front to be endangered by such caving.

From about Station 630 to Station 750 the caving ranges from 1 to 300 feet. Along this stretch the levee is from 350 to 800 feet from the river bank. A small amount of new levee will be needed at one or two points during the next one or two years.

Gaines Landing to Point Comfort (550 to 555 R.).—The point of maximum caving in this bend has moved down about 1 mile, being now about 1 mile below Station 1729, the upper end of the Panther Forest Short Line, where it has caved 1,000 feet during the last four years. Opposite Station 1729 the rate has been about 500 feet in that time.

The levee stands 1,300 feet back from the river bank at this point. With the present downward tendency of the caving it will not be endangered for a good many years.

Linwood to Upper Leland (464 to 472 R.).—The maximum caving occurred opposite Station 1856, where it amounts to about 300 feet. The levee at this point is about 1,200 feet from the river bank.

From Stations 1900 to 2040 the caving has been very nominal. From Stations 2040 to 2205 it has been about 300 feet, or about 75 feet per year. At the present rate the present line of levee there will last three or four years. A location has been made, however, and an estimate given for a new line across the neck.

Vaucluse to Sunnyside (487 to 490 R.).—The greatest caving has taken place in front of the big Whisky Chute Levee, Station 2537, where it caved 300 feet, bringing it to within 800 feet of the levee. No very great caving has taken place here during the last eighteen months, and there is a tendency to work farther down in the bend. If it should continue to encroach on the Whisky Chute Levee, it should by all means be protected by bank revetment, as there is no new location practicable except to go around Lake Chicot. This matter, however, has been treated in a special report.

Harwood Island to Grand Lake (506 to 510 R.).—The caving in this bend has been pretty general from Stations 3386 to 3752, the point of greatest caving being at Station 3551, where the levee is still 1,700 feet back. The caving amounted to 600 feet.

From Stations 3677 to 3732 the levee is from 1,200 to 900 feet back from the bank. The caving along this stretch amounts to 250 to 350 feet in the last four years.

Cottonwood to head of Lake Providence revetment (535 to 541 R.).—Stations 1052 to 1118 the caving has been about 300 feet, necessitating a loop of about 58 stations, which was built by the State. Another loop of about 26 stations will be required from Station 1042 to connect near Station 1090 on the Cottonwood loop. Very slight caving has occurred from Stations 1118 to 1207.

From Stations 1225 to 1257 the caving has ranged from 200 to 600 feet during the last four years. The point of maximum caving is in front of Station 1234, where the caving is within about 400 feet of the levee.

The point most threatened at present is at Station 1278, where the caving is within less than 200 feet of the levee.

Some new work will be necessary along this stretch in the next year.

Goodrich Landing to Willow Point (562 to 567 R.).—Very rapid and continued caving has taken place in this bend from Stations 2466 to 2673. The stretch of greatest caving extends from Stations 2529 to 2642, where it ranges from 2,000 to 2,200 feet. Some new levee will be required here.

Henderson to Cabin Teele (574 to 585 R.).—More or less caving has taken place

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throughout this entire bend. From Stations 2920 to 3031 the caving has been about 1,000 feet. A small loop will probably be necessary at Station 3031. The greatest caving occurred between Stations 3370 and 3550, being about 1,000 feet at the upper station and 2,300 feet at the lower point. A loop will be required here.

Duckport to Youngs Point (590 to 594 R.).—Caving from 200 to 800 feet has occurred from Stations 3687 to 3970. A new loop will be required from Stations 3730 to 3762; also one in the vicinity of Station 3970.

Reeds to Bedford (602 to 606 R.).—Caving has been continuous from Stations 4382 to 4619, the point of greatest caving being at the lower end, where it has been 2,500 feet during the last four years.

NEW LEVEES PROBABLY REQUIRED WITHIN THREE YEARS.

In Arkansas.—The old levee from Stations 630 to 750 is more or less threatened by caving. From Stations 800 to 900 the levee was originally built on an old railroad bed, which was no doubt a very bad beginning. The location is along the bank of a false chute, which makes further enlargement very expensive. The section is very inferior, without banquette of any consequence, banquette having been washed away by heavy rains. This stretch seeps badly and is, in fact, a menace to the entire system. While it is possible to make this line secure and to temporize with small loops from Stations 630 to 750 for some years, it will, in my opinion, be decidedly better to build a new line from about Station 600 to Station 900, running back of Cypress Lake. A survey was made for this new location and an estimate made which will be given below.

From Stations 2096 to 2146 was formerly enlarged to 3 feet above the high water of 1890. Since that time it has been topped and retopped until its slopes are very inferior and its crown only 3 feet wide. In addition to this there is a stretch of levee on the lower side of the neck that is dangerously near the river bank and very much exposed to wave wash. In view of these facts a location has been made for a new line from Stations 2047 to 2442, which would be 83 stations in length and would throw out 328 stations. The estimate is listed below.

In Louisiana.—Stations 1042 to 1080, the levee is only 150 to 500 feet from the river bank, and will very probably have to be looped. A location and an estimate have been made. Stations 1225 to 1372 are along a caving bank, the greatest danger being along the lower half from Stations 1278 to 1372. This part will, at the present rate of caving, be endangered during the next year. But as the caving has had a very marked tendency to work upstream during the last year, it will not be wise to begin a loop lower than Station 1225. A partial location was made and an estimate obtained from the best information available for this loop. It will necessarily be a very expensive loop. Surveys were also made to locate a line from Station 500, on Old River, to the lower end of this stretch. This line would be permanent, 247 stations in length, and would shorten the line 625 stations.

Comparative estimates of these two lines, together with the valuation and amount of the property thrown out, were submitted in a special report.

The levee from Stations 2466 to 2670 is more or less endangered by caving and is very much exposed to wave wash.

At the present rate of caving nearly this entire line, and probably an extension of it, will have to be rebuilt during the next two or three years. It is considered advisable to build a cross line, beginning at Station 2466 and ending at Station 2929, on the lower side of the neck. This line will be 248 stations in length and would shorten the line 215 stations. Estimate submitted. Property interests given in a special report.

The levee at Station 3550, and for some distance above, will probably be endangered in the next two years. An estimate is given for new loop beginning at Station 3370 and ending about Station 3589. This line will be about 100 stations long and will shorten original line 119 stations.

From about Station 3724 to Station 3762 a new loop will probably be necessary.

Tabulation of the above work.

Stations.	Miles below Cairo.	Levee.	Banquette.	Total.	Remarks.
		Cu. yds.	*Cu. yds.*	*Cu. yds.*	
600–900	430–438 R.	661,987	81,000	742,987	
2047–2130	469–485 R.	805,943	40,700	846,643	Station 2130 = 2442 present line.
1042–1068	535 R.	77,846	9,032	86,878	Station 1068 = 1090 present line.
1225–1389	537–540 R.	683,696	89,302	772,998	Station 1389 = 1372 present line.
2466–2714	564–574 R.	985,646	125,498	1,111,144	Station 2714 = 2929 present line.
3370–3470	584 R.	823,200	35,000	858,200	Station 3470 = 3598 present line.
3724–3759	590 R.	94,360	10,150	104,510	Station 3759 = 3762 present line.
Total		3,132,678	390,682	3,523,360	

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Estimated yardage to bring the entire line up to a grade 3 feet above high water of 1897, standard section, is as follows, not including the above stretches covered by proposed new loops.

Stations.	Enlargement.	Banquette.	Total.	Remarks.
In Arkansas.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	
0–655	457,536	140,799	598,335	Arkansas River levees.
0–265	927,018	1,057,143	1,984,161	Amos Bayou line.
0–4210				Main line.
Total	1,384,554	1,197,942	2,582,496	
In Louisiana.				
0–4619	673,800	887,760	1,561,560	
Total	2,058,354	2,085,702	4,144,056	

To bring the portions of the present line covered by the proposed new loops to the 3-foot grade would require 97,000 cubic yards enlargement and 162,116 cubic yards banquette, or a total of 259,116 cubic yards.

The total estimates for the 3-foot grade therefore become:

	Cubic yards.
With loops	7,667,416
Without loops	4,403,172

Estimate for ultimate commission grade.—This is based on average height of new commission grade at White River and Arkansas City, Arkansas City and Greenville, Greenville and Lake Providence, Lake Providence and Vicksburg, and applying these averages to the local high water along the line between these respective points, thus giving the following approximate estimates in Arkansas and Louisiana:

IN ARKANSAS.

Stations.	Kind of work.	Cubic yards.	Price.	Total cost.	Remarks.
			Cents.		
0–268	Enlargement	5,841,158	18.8	$1,098,137.70	Amos Bayou line.
0–4210					Main line.
600–816	New levee	1,249,279	16.0	199,884.64	Covers Stations 600–900.
2047–2131	do	452.453	16.0	72,392.48	Covers Stations 2047–2442.
0–268	Banquette	1,778,721	12.0	213,446.52	
0–4210					
Total		9,321,611		1,583,861.34	

IN LOUISIANA.

0–4619	Enlargement	6,927,949	18.8	1,302,454.41	
0–4619	Banquette	2,293,336	12.0	275,200.32	
Total		9,221,285		1,577,654.73	

Average cost of work, 17 cents per cubic yard.

Ten per cent added to all work for contingencies.

Summary.

Arkansas and Louisiana:	
Total cubic yards	18,542,896
Total cost	$3,161,516.07

UPPER TENSAS DISTRICT IN ARKANSAS AND LOUISIANA.

Statement of material in levees May 1, 1898, to May 1, 1899.

	Cubic yards.
Red Fork Levee, May 1, 1898	588,333
Costello's gin to the Louisiana line	10,508,898
Louisiana line from State line to end of district	12,944,919
Total May 1, 1898	24,042,150

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Material added:	Cubic yards.
United States, May, 1898 to 1899, contracts in Arkansas.....	742,251
United States, May, 1898 to 1899, contracts in Louisiana	714,339
By Tensas Basin board in Arkansas	118,500
By State and Fifth Louisiana Levee district in Louisiana ...	498,582
	2,073,672
Total yardage May 1, 1899	26,115,822

Banquettes.—This subject has been discussed fully and often, but I consider it of such vital importance to the safety of the levee interests, that it should be kept constantly in mind in connection with all projects for levee improvement.

The estimate for the 3-foot grade shows that there is required now about 2,247,818 cubic yards for banquettes in the Upper Tensas district in Arkansas and Louisiana. This is very little less than it was at the last annual report.

I do not consider that large levees of the ordinary section without banquettes can be considered secure against large floods of long duration.

Miscellaneous.—Levee survey was made on the main line in Arkansas (Stations 0 to 4210) to determine the present crown elevation, and over the entire line in Louisiana (Stations 0–4619). This survey consisted of making a cross-section of the levee every 500 feet, and oftener when necessary, to determine the yardage necessary to raise it to an increased grade. Topography along each side of the levee was carefully sketched in. In making the Arkansas River survey, as well as the shore-line surveys, a small quarter boat was used for the accommodation of the men, and a 4-horsepower gasoline launch was used for towing downstream. This proved to be very satisfactory, and is much better than camping in tents or trying to get accommodation from house to house, which, owing to the sparsely settled condition of the country, makes it almost impossible to obtain quarters except at a great hardship to the party. A small steamboat adapted to such work would be the best arrangement for future surveys of this nature.

A location was made for an experimental seep ditch along the levee on Lower Leland Front. This was to be constructed by the local interests, but was abandoned on account of the high water.

Caving.—Since the shore-line surveys in February and March a small cave has taken place at Delta Point near the Vicksburg, Shreveport and Pacific Railroad incline. The railroad officials have treated this by driving piles in front of the slough and filling in back with brush and sacks of earth. Up to this date there are no further developments.

Arkansas River Levee, Red Fork.—I give below an extract from a letter from Mr. G. E. Buck, secretary of the Red Fork Levee board:

"With the exception of emergency work incident to high water during the spring of 1898 and repairs to damaged line from this flood, amounting to $1,627.15, our board has done no work on the levees during the year from May 1, 1898, to May 1, 1899. The funds for the district have been held to apply to the extension of the levee below Red Fork, in conjunction with the local boards below. This work was contemplated for last fall, but has progressed no further than the letting at this writing. Our board will have $6,000 for this year's expenditures, in conjunction with the district below. This will be used for extension of the present levee in the direction of the mouth of Cypress Creek. If the commission will undertake this extension work, we propose, with the aid of the lower districts, to get the levee from Red Fork up in first-class shape."

A blue print[1] showing overflowed area accompanies this report in a separate package.

A list[1] of expenditures of the United States Government, the Desha, Chicot, Tensas Basin, and the Fifth Louisiana Levee boards, and the State of Louisiana, together with tables showing cost of construction,[1] condition of work[1] at the end of the fiscal year, labor statements, and a statement[1] of labor and material in high water-protection, are inclosed.

I wish to thank the local boards for prompt and efficient services, and my assistants for their efficient and faithful performance of duty.

Respectfully submitted.

E. C. TOLLINGER,
Assistant Engineer.

Capt. H. C. NEWCOMER,
Corps of Engineers, U. S. A.

[1] Omitted.

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Levee work in Upper Tensas Levee district, in Arkansas, May 1, 1898, to May 1, 1899.

[E. = Enlargement; N. = New; T. = Topping; B. = Banquette.]

Stations.	Miles below Cairo.	Contractors.	Cubic yards in contract.	Cubic yards placed during year.	Total laborers.	Total teams.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard (cents).	Average heights (feet).	Average haul (feet).	Kind of work.
84– 43	426 R.	Andy Tracy.....	4,944	4,944	294	192	127	26	39	14.5	16	150	E.
150– 214	405 R.	Lacy & Whitehill.	3,203	3,203	280	161	145	20	22	27	12	200	T.
180– 230	425 R.	J. M. Whitehill....	20,734	2,638	176	117	102	23	26	13	14	225	B.
420– 484	427 R.	W. M. Bates.....	54,000	42,400	2,875	1,908	1,296	22	33	13.5	14	200	E.
520– 605	429 R.	L. C. Dresbach & Bro.	66,000	38,100	2,302	1,474	1,100	26	35	17.93	12	175	E.
605– 630	430 R.	W. M. Forrest.....	2,500	800	64	47	36	17	22	21	17	400	T.
630– 660	430 R.	J. M. Whitehill....	45,000	29,900	1,842	1,290	854	23	35	12	12	175	E. and B.
680– 710	431 R.	Lacy & Whitehill.	9,646	9,646	456	307	226	31	43	11.49	10	150	B.
710– 750	432 R.	C. A. Lacy.....	18,992	18,992	802	525	335	36	57	8.99	10	100	B.
906– 931	438 R.	Geo. R. Lacy	20,000	13,300	889	562	388	34	34	21.99	10	200	E.
1080–1200	441 R.	J. M. Whitehill....	109,000	5,600	919	665	500	8	11	13.99	12	175	E.
1200–1240	442 R.	W. M. Forrest.....	33,000	9,000	734	432	278	21	32	17.90	12	175	E.
1240–1490	444 R.	C. O. Greenlee.....	20,181	20,181	1,161	803	575	25	35	20	....	150	T.
1490–1510	449 R.	C. A. Winter.....	14,998	14,998	1,033	700	520	21	29	14.375	14	350	E.
1730–1740	451 R.	Cary & Johnsen ..	5,724	5,724	446	301	187	19	31	17.49	16	250	E.
1740–1780	452 R.	Shippey & Johnsen	58,105	58,103	4,125	2,748	1,868	21	31	15.9	22	250	E.
1780–1810	466 R.	Robert Johnsen...	20,000	4,312	412	256	191	17	22	11.99	14	300	E.
1810–1941	466 R.	J. V. Daugherty...	160,000	44,601	2,903	2,035	1,337	21	33	16	17	300	E. and B.
1826–1831	466 R.	J. E. Moore.....	3,019	3,019	131	80	56	38	54	16	7	175	B.
1942–2047	468 R.	McCadden & Ronch	81,905	39,391	a2,799	1,266	799	25	40	14.95	14	225	E.
2740–2850	490 R.	W. R. Lewis & Co.	75,000	49,838	2,559	1,741	1,225	29	41	12.98	11	200	E.
2850–3065	494 R.	.....do.....	29,814	29,814	1,654	1,068	759	28	39	12.98	....	200	T.
3065–3100	496 R.	W. M. Bates.....	31,049	25,033	1,422	1,018	701	24	36	14	17	300	E.
3100–3160	496 R.	.....do.....	60,000	37,416	2,201	1,524	1,042	25	36	11	16	250	E.
3160–3185	498 R.	W. M. Bates & Co.	21,378	21,378	1,521	1,094	662	20	32	15	16	200	E.
3185–3400	498 R.	Stone & Stansell ..	21,029	21,029	1,398	1,003	659	21	32	24.94	....	150	T.
3400–3500	505 R.	C. A. Winter	75,000	65,841	3,750	2,719	1,819	24	36	13.625	15	300	E.
3500–3600	506 R.	.....do.....	104,000	36,843	2,495	1,736	1,142	21	32	15	16	300	E.
3600–3700	508 R.	Ben Talley.....	94,000	34,404	2,183	1,435	879	24	39	15	16	300	E.
3700–3760	509 R.	W. M. Bates.....	50,582	50,582	1,866	1,340	903	38	56	12.50	16	250	E.

a 793 wheelbarrows; average, 11 cubic yards.

Respectfully submitted.

E. C. TOLLINGER, *Assistant Engineer.*

GREENVILLE, MISS., *May 1, 1899.*

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Levee work in Upper Tensas Levee district, in Louisiana, May 1, 1898, to May 1, 1899.

[E.=Enlargement; N.=New; T.=Topping; B.=Banquette.]

Stations.	Miles below Cairo.	Contractors.	Cubic yards in contract.	Cubic yards placed during year.	Total laborers.	Total teams.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard (cents).	Average height (feet).	Average haul (feet).	Kind of work.
0–256	520 R.	Arnold & DeGaris	165,305	29,335	.....	.....	.....	34	45	12.40	17	100	E.
2411–2500	562 R.	L. Aschaffenburg	98,266	59,043	a 4,226	2,897	2,103	20	28	15.74	17.6	245	E.
2500–2601	564 R.	W. M. Bates	83,880	46,337	2,815	1,935	1,408	24	33	14	17.2	180	E.
2810–2931	574 R.	J. H. McTighe	99,235	73,865	3,760	2,676	1,829	28	40	9.99	15.2	132	E.
2931–3031	576 R.	W. J. Bentley & Co.	97,225	53,223	b 4,253	2,064	1,471	26	36	18.60	15.7	179	E.
3031–3118	577 R.	Geo. B. Vaughan	67,807	56,852	2,452	1,896	1,294	30	44	8.94	14.8	150	E.
3118–3197	579 R.	W. M. Bates	81,101	24,182	c 2,095	1,074	796	23	30	17	18.8	200	E.
3197–3277	580 R.	A. S. Coltharp	76,009	42,491	2,412	1,770	1,241	24	34	11.45	17.5	185	E.
3277–3310	580 R.	.....do	10,879	10,879	586	435	316	25	34	8.45	4.3	135	B.
3310–3328	582 R.	Geo. B. Vaughan	12,503	504	38	28	20	18	25	9.45	14	.....	E.
3328–3428	582 R.	J. C. Hodge	121,179	73,908	3,962	3,052	2,005	24	36	12.5	16	225	E.
3428–3550	583 R.	Timothy Sullivan	106,806	54,204	3,181	2,467	1,656	22	33	11.74	14.1	200	E.
4409–4432	603 R.	J. S. McTighe B. C. and I. L. Co.	21,472	21,472	1,697	1,147	745	19	29	18.2	18	225	E.
4432–4452	603 R.	E. Hyner	104,371	20,304	d 2,153	885	648	18	25	27.5	18	225	N.
4452–4472	603 R.	.....do	131,008	43,440	e 3,741	1,137	913	20	25	27.5	19	270	N.
4472–4492	604 R.	.....do	115,563	52,149	f 5,422	886	613	24	35	27.5	19	200	N.
4492–4507	604 R.	.....do	87,426	15,801	g 2,271	603	386	16	25	27.5	19	250	N.
4507–4540	604 R.	J. S. McTighe B. C. and I. L. Co.	750	750	h 360	.....	.....	.....	.....	23	.....	.....	T.
4540–4551	605 R.	Arnold, DeGaris & Co.	91,189	28,942	i 6,322	.....	.....	.....	.....	36.75	22	400	N.
4551–4570	605 R.	J. S. McTighe B. C. and I. L. Co.	3,978	3,978	j 2,214	.....	.....	.....	.....	19.5	.....	.....	T.

a 624 wheelbarrows.
b 507 wheelbarrows.
c 57 wheelbarrows.
d 800 wheelbarrows; average, 8 cubic yards.
e 1,905 wheelbarrows; average, 6 cubic yards.
f 3,647 wheelbarrows; average, 6 cubic yards.
g 1,073 wheelbarrows; average, 5 cubic yards.
h 267 wheelbarrows; average, 2.8 cubic yards.
i 5,058 wheelbarrows; average, 6 cubic yards.
j 1,564 wheelbarrows; average, 2.5 cubic yards.

Respectfully submitted.

E. C. TOLLINGER, *Assistant Engineer.*

GREENVILLE, MISS., *May 1, 1899.*

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Statement of levee contracts undertaken by the State and the Fifth Louisiana Levee district during the season of 1898–99, along the Mississippi River between the Arkansas State line and Bedford Landing, Louisiana.

[E.=Enlargement; N.=New; T.=Topping.]

Stations.	Miles below Cairo.	Kind of work.	Contractor.	Cubic yards in contract.	Cubic yards in place.	Price per cubic yard.	Average height.
						Cents.	*Feet.*
0–192	521 R..	E.	F. L. Maxwell	38,000	7,000	14	14.1
930–1080	533 R..	E.	Robt. Nicholson	64,300	45,000	15.18	12.8
1190–1260	538 R..	E.					
1260–1294	538 R..	T.	do	46,300	38,000	14.52	15
1294–1300	538 R..	E.					
1300–1459	540 R..	E.	do	122,500	90,000	15.94	14.2
1636–1679	545 R..	E.	do	25,300	17,000	17.44	17.7
1725–1840	546 R..	E.	F. L. Maxwell	120,500	43,000	13.60	16.9
2600–2640	565 R..	N.	Robt. Nicholson	a122,500	122,000	19.21	16.1
3563–3607	587 R..	T.	F. L. Maxwell	8,582	8,382	13	7.7
3644–3680	587 R..	T.					
3680–3709	590 R..	N.	J. G. Boney	b68,592	68,000	10.15	11.3
3840–4226	592 R..	E.	F. L. Maxwell	351,388	c300,656	12.75	14.4
3709–3734	592 R..	N.	do	d51,791	51,791	12.75	14.4
4225–4397	601 R..	E.	do	98,618	59,700	14.90	13.8

a Length of levee, 3,500 feet.
b Length of levee, 3,865 feet.
c A large portion of this work was placed during season of 1897–98.
d Length of levee, 3,380 feet.

NOTE.—"Average height" is from top of levee to foot of slope on side of enlargement.

Respectfully submitted.

E. C. TOLLINGER,
Assistant Engineer.

GREENVILLE, MISS., *May 1, 1899.*

Cost of work done by the United States in the Lower Yazoo Levee district from 1882 to May 1, 1899.

Stations.	Miles below Cairo.	Contractor.	Cubic yards.	Cost.
		Levee construction, 1882 to May 1, 1898	c11,103,926	d$1,782,064.93
		Levee construction, May 1, 1898, to May 1, 1899:		
		Above Greenville—		
300–400	372 L ...	Ernest Hyner	35,644	4,633.72
500–600	375 L ...	E. B. Mantle	21,010	2,521.20
900–993	379 L ...	J. C. Neely	20,986	1,857.26
1037–1058	392 L ...	Hugh Morgan	4,660	442.70
1037*b*–1200	392 L ...	Stone & Stansell	87,916	13,609.39
1202–1235	394 L ...	Hugh Morgan	8,580	810.35
1491–1530	399 L ...	T. Sullivan & Co	13,194	1,180.86
1870–1980	403 L ...	T. Sullivan & Co	27,848	2,492.40
2005–2066	404 L ...	Robert Johnsen	17,920	1,566.21
2700–2800	419 L ...	McCadden & Roach	85,033	e10,399.53
2800–2880	420 L ...	Ernest Hyner	90,955	10,914.60
3000–3100	431 L ...	Ernest Hyner	89,284	10,714.08
3100–3187	433 L ...	Ernest Hyner	33,921	5,427.36
3166–3186	433 L ...	T. Sullivan & Co	10,306	1,236.72
3201–3215	434 L ...	Ben Talley	31,729	12,439.80
3306–3329	436 L ...	Jas. H. Cary	16,175	2,021.88
3329–3360	436 L ...	McIntyre & Howard	126,716	e16,447.44
3360–3400	436 L ...	P. F. Lamb	86,460	11,672.11
3400–3440	436 L ...	McLeod & McCarten	32,326	4,105.30
3469–3514	436 L ...	McLeod & McCarten	44,090	5,599.42
3890–3930	445 L ...	Arnold & DeGaris	8,252	e1,328.57
4150–4200	459 L ...	Arnold & DeGaris	27,083	e4,265.57
4200–4300	460 L ...	Ben Talley	136,348	19,020.55
4300–4400	475 L ...	McCadden & Roach	64,232	8,607.09
4400–4500	476 L ...	Timothy Sullivan	80,578	e10,434.20

c Includes 23,178 cubic yards not reported last year.
d Includes $29,095.45 not reported last year.
e Unfinished.

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Cost of work done by the United States in the Lower Yazoo Levee district from 1882 to May 1, 1899—Continued.

Stations.	Miles below Cairo.	Contractor.	Cubic yards.	Cost.
		Levee construction, May 1, 1898, to May 1, 1899—Continued.		
		Below Greenville—		
0- 60	479 L ...	Timothy Sullivan	2,780	$1,051.35
6- 100	479 L ...	C. A. Winter	2,949	293.43
60- 100	480 L ...	L. C. Dulaney	39,776	4,069.08
100- 150	480 L ...	T. Mike	38,393	3,739.47
100- 200	480 L ...	Jno. G. Sessions	12,285	1,226.04
150- 200	481 L ...	T. Mike	30,619	2,893.50
200- 300	483 L ...	H. F. Watkins	46,981	c4,608.10
300- 400	485 L ...	Jno. G. Sessions	56,070	5,887.35
400- 500	487 L ...	J. H. McTighe	43,310	c5,413.75
500- 600	489 L ...	T. Mike	58,029	c5,071.73
600- 700	491 L ...	C. A. Winter	64,782	8,988.50
700- 790	492 L ...	C. A. Winter	44,124	c5,901.58
811- 900	492 L ...	John C. McIntyre	43,786	c7,279.42
900-1000	493 L ...	J. B. Lewis	98,641	c13,069.93
1000-1100	494 L ...	J. B. Lewis	69,256	c7,051.46
1070-1130	495 L ...	J. E. Kerr	26,208	3,013.92
1100-1200	495 L ...	T. Mike	43,058	c4,090.03
1200-1300	497 L ...	T. Mike	27,409	c2,738.16
1300-1400	499 L ...	Robert Johnsen	57,546	c8,056.44
1400-1500	500 L ...	M. McTighe	88,247	c15,884.46
1500-1600	502 L ...	John C. McIntyre	62,961	c9,680.25
1600-1700	503 L ...	Ben Talley	30,117	c4,216.38
1700-1800	504 L ...	H. F. Watkins	17,500	c2,009.00
1800-1900	505 L ...	J. & A. Wynn	63,952	c6,395.20
1900-2000	512 L ...	Martin Jennings & Co	47,812	5,677.68
2000-2060	513 L ...	Chas. T. Worthington	111,951	11,055.16
2060-2110	514 L ...	Ben Talley	100,175	10,017.50
2400-2571	527 L ...	J. E. Kerr	29,250	c4,095.00
3169-3184	537 L ...	Robert Johnsen	26,120	4,100.84
4078-4133	554 L ...	Shippey & Kilpatrick	94,382	c13,911.91
4133-4188	555 L ...	Shippey & Kilpatrick	97,321	c14,345.11
4188-4243e	555 L ...	Shippey & Kilpatrick	61,366	c9,045.34
		Total construction, May 1, 1898, to May 1, 1899	2,845,342	d368,715.68
		Total construction, 1882 to May 1, 1899	13,949,268	2,100,780.61
		High-water protection, repairs, and engineering expenses, 1882 to May 1, 1898		e325,801.72
		High-water protection, repairs, and engineering expenses, May 1, 1898, to May 1, 1899		44,436.87
		Total high-water protection, repairs, and engineering expenses, 1882 to May 1, 1899		370,238.59
		Total cost, 1882 to May 1, 1899		d2,471,019.20

c Unfinished.
d Includes liabilities not paid, amounting to $36,755.17.
e Includes $11,797.08 not reported last year.

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Cost of work done by the United States in the Upper Tensas Levee district from 1882 to May 1, 1899.

Stations.	Miles below Cairo.	Contractor.	Cubic yards.	Cost.
		Levee construction, 1882 to May 1, 1898	a 16,802,877	b $2,785,794.77
		Levee construction, May 1, 1898, to May 1, 1899:		
		Arkansas—		
34- 43	426 R	Andy Tracy	4,944	716.88
150- 214	405 R	Lacy & Whitehill	3,203	864.81
180- 230	425 R	J. M. Whitehill	5,894	766.22
420- 484	427 R	W. M. Bates & Co	42,376	c 5,720.76
520- 605	429 R	L. C. Dresbach & Bro	38,117	c 6,854.37
605- 630	430 R	Wm. M. Forrest	810	c 188.00
630- 660	430 R	J. M. Whitehill	29,947	c 3,593.64
680- 710	431 R	Lacy & Whitehill	9,646	1,108.33
710- 750	432 R	C. A. Lacy	18,992	1,707.38
906- 931	438 R	Geo. R. Lacy	13,312	c 2,927.30
1080-1200	441 R	J. M. Whitehill	8,223	c 1,150.40
1200-1240	442 R	Wm. M. Forrest	8,984	c 1,608.13
1240-1490	444 R	C. O. Greenlee	20,181	4,036.20
1490-1510	449 R	C. A. Winter	14,998	2,155.96
1730-1740	451 R	Cary & Johnsen	5,724	1,001.13
1740-1780	452 R	Shippey & Johnsen	58,105	9,238.70
1780-1810	466 R	Robert Johnsen	4,312	c 517.00
1810-1941	466 R	J. V. Daugherty	50,644	c 8,103.04
1826-1831	466 R	J. E. Moore	3,019	483.04
1942-2047	468 R	McCadden & Roach	39,391	c 5,888.95
2740-2850	490 R	W. R. Lewis & Co	49,838	c 6,468.97
2850-3065	494 R	W. R. Lewis & Co	29,814	3,869.86
3065-3100	496 R	W. M. Bates & Co	25,033	c 3,504.62
3100-3160	494 R	W. M. Bates	37,416	c 4,115.76
3160-3185	498 R	W. M Bates & Co	21,378	3,206.70
3185-3400	496 R	Stone & Stansell	21,029	5,244.63
3400-3500	505 R	C. A. Winter	65,861	c 8,973.56
3500-3600	506 R	C. A. Winter	36,843	c 5,526.45
3600-3700	508 R	Ben Talley	34,404	c 5,160.60
3700-3760	509 R	W. M. Bates	50,582	6,322.76
		Louisiana—		
0- 256	520 R	Arnold & DeGaris	982	121.73
2411-2500	562 R	L. Aschafienburg	59,043	c 9,293.36
2500-2601	564 R	W. M. Bates	46,337	c 6,487.18
2810-2931	574 R	J. H. McTighe	73,865	c 7,379.11
2931-3031	576 R	W. J. Bentley & Co	53,223	c 9,899.47
3031-3118	577 R	Geo. B. Vaughan	56,852	c 5,082.56
3118-3197	579 R	W. M. Bates	24,182	c 4,110.94
3197-3277	580 R	A. S. Coltharp	42,491	c 4,865.41
3277-3310	581 R	A. S. Coltharp	10,879	919.28
3310-3328	582 R	Geo. B. Vaughan	191	18.05
3328-3428	582 R	J. C. Hodge	73,908	c 9,238.50
3428-3550	583 R	Timothy Sullivan	81,635	9,583.93
4409-4432	603 R	J. S. McTighe B. C. & I. L. Co	21,472	3,907.90
4432-4452	603 R	Ernest Hyner	26,561	7,304.26
4452-4472	603 R	Ernest Hyner	41,813	11,498.58
4472-4492	604 R	Ernest Hyner	52,149	14,340.98
4492-4507	604 R	Ernest Hyner	15,800	4,344.99
4540-4551	605 R	Arnold, DeGaris & Co	41,158	c 15,125.56
4551-4570	605 R	J. S. McTighe B. C. & I. L. Co	3,978	c 1,193.40
		Total construction, May 1, 1898, to May 1, 1899	1,479,539	235,719.34
		Total construction, 1882 to May 1, 1899	18,282,416	3,021,514.11
		High-water protection, repairs, and engineering expenses, 1882 to May 1, 1898		614,134.65
		High-water protection, repairs, and engineering expenses, May 1, 1898, to May 1, 1899		40,202.79
		Total high-water protection, repairs, and engineering expenses, 1882 to May 1, 1899		654,337.44
		Total cost, 1882 to May 1, 1899		d 3,675,851.55

a Includes 2,680 cubic yards not reported last year.
b Includes $22,844.42 not reported last year.
c Unfinished.
d Includes liabilities not paid, amounting to $42,228.08.

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Financial statement.

ASHBROOK NECK.

Balance unexpended June 30, 1898	$7,677.05
Expended to June 30, 1899	6,998.14
Balance unexpended June 30, 1899 (in hand and available)	678.91
Expenditures apportioned:	
Material for construction	1,538.78
Labor on construction	810.28
Cost and care of plant, outfit, and supplies	2,095.93
Towage and steamer expense	927.05
Administration and office expense	1,336.83
Subsistence	289.27
Total	6,998.14
Amount that can be profitably expended during fiscal year ending June 30, 1901	30,000.00

GREENVILLE, MISS.

Balance unexpended June 30, 1898	$1,965.57
Allotted during year	100,000.00
Total	101,965.57
Expended to June 30, 1899	101,534.98
Balance unexpended June 30, 1899 (in hand and available)	430.59
Expenditures apportioned:	
Material for construction	47,646.03
Labor on construction and superintendence	42,706.87
Cost of plant, outfit, and supplies	1,521.18
Administration and office expenses	2,774.25
Subsistence	6,886.65
Total	101,534.98
Amount that can be profitably expended during fiscal year ending June 30, 1901	20,000.00

LAKE PROVIDENCE REACH.

Balance unexpended June 30, 1898	$14,394.24
Allotted during year	10,000.00
	24,394.24
Amount transferred to New Orleans Harbor	10,000.00
Total	14,394.24
Expended to June 30, 1899	13,501.08
Balance unexpended June 30, 1899 (in hand and available)	893.16
Expenditures apportioned:	
Material for construction	5,246.89
Labor on construction and superintendence	4,580.47
Cost and care of plant, outfit, and repairs	64.80
Towage and steamer expenses	2,031.41
Administration and office expenses	593.44
Subsistence	984.07
Total	13,501.08
Amount that can be profitably expended during fiscal year ending June 30, 1901	20,000.00

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DELTA POINT.

Balance unexpended June 30, 1898	$2,745.72
Allotted during year	40,000.00
Total	42,745.72
Expended to June 30, 1899	2,083.21
Balance unexpended June 30, 1899 (available)	40,662.51
In Treasury	25,000.00
In hand	15,662.51
	40,662.51
Expenditures apportioned:	
Material for construction	2,044.21
Administration and office expenses	39.00
Total	2,083.21
Amount that can be profitably expended during fiscal year ending June 30, 1901	20,000.00

LOWER YAZOO LEVEE DSITRICT.

Balance unexpended June 30, 1898	$142,106.02
Allotted during year	357,000.00
Amount received on account overpayment	7.36
Total	499,113.38
Expended to June 30, 1899	391,393.17
Balance unexpended June 30, 1899	107,720.21
In Treasury	100,300.00
In hand	7,420.21
	107,720.21
Amount covered by existing contracts and liabilities	107,720.21
Expenditures apportioned:	
Levee construction	351,900.73
Engineering and office expenses, high-water protection and repairs	39,492.44
Total	391,393.17
Amount that can be profitably expended during fiscal year ending June 30, 1901	500,000.00

UPPER TENSAS LEVEE DISTRICT.

Balance unexpended June 30, 1898	$179,430.01
Allotted during year	215,000.00
Amount received on account overpayment	.44
Total	394,430.45
Expended to June 30, 1899	252,934.99
Balance unexpended June 30, 1899	141,495.46
In Treasury	135,000.00
In hand	6,495.46
	141,495.46
Amount covered by existing contracts and liabilities	141,495.46

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Expenditures apportioned:	
Levee construction	$219,826.53
Engineering and office expenses, high-water protection and repairs	33,108.46
Total	252,934.99
Amount that can be profitably expended during fiscal year ending June 30, 1901	500,000.00

SURVEYS, GAUGES, AND OBSERVATIONS.

Balance unexpended June 30, 1898	$248.41
Expended to June 30, 1899	248.41
Expenditures apportioned:	
Material and stationery	69.42
Subsistence	178.99
Total	248.41
Amount that can be profitably expended during fiscal year ending June 30, 1901	5,000.00

STONE.

Balance unexpended June 30, 1898	$9,087.18
Expended to June 30, 1899	9,087.18
Expenditures apportioned:	
Stone	5,176.82
Towing stone and unloading same	647.01
Cost and care of plant, outfit, and supplies	109.20
Administration and office expenses	1,061.54
Subsistence	92.61
Purchase of quarry	2,000.00
Total	9,087.18
Amount that can be profitably expended during fiscal year ending June 30, 1901	30,000.00

PLANT.

Balance unexpended June 30, 1898	$48,978.75
Allotted during year	20,000.00
Total	68,978.75
Expended to June 30, 1899	67,883.28
Balance unexpended June 30, 1899 (in hand and covered by outstanding liabilities)	1,095.47
Expenditures apportioned:	
Cost of steamer *Arthur Hider*, including outfit	37,450.00
Material for repairs, outfit, and supplies	2,713.11
Care of plant, and labor on repairs	21,901.58
Administration and office expenses	1,319.17
Subsistence	4,499.42
Total	67,883.28
Amount that can be profitably expended during fiscal year ending June 30, 1901	30,000.00

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Abstract of proposals for levee work in Lower Yazoo Levee district below Greenville, received and opened by Capt. H. C. Newcomer, Corps of Engineers, July 6, 1898.

No.	Name of bidder.	Stations 200–300 (483 L.).	Stations 300–400 (485 L.).	Stations 400–500 (487 L.).	Stations 500–600 (489 L.).	Stations 600–700 (491 L.).	Stations 700–790 (492 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	J. H. Cary	11	13	13	10.45	15	20
2	John Scott & Sons	11	14	.....	14.5	.....	19.45
3	L. C. Dresbach & Bro	12.75	.....	.....	11.75	.....	.....
4	J. E. Moore	.....	11.375	.....	9.125	14.45	.....
5	Shippey & Kilpatrick	14	14	14	14	.....	.....
6	J. & A. Wynn	9	.....	22.5	11	.....	.....
10	T. Mike	9.2	13	13.5	a 8.74	13	.....
11	Hugh Morgan	12.5	12.5	.....	12.5	.....	.....
12	Green Clay	12.75	10.8	13.9	14	14.87	15
14	Aderholdt & Lowrance	13	15.5	13.75	13.5	20.75	20.75
15	C. A. Winter	.....	.....	.....	.....	a 13.875	a 13.875
17	W. M. Bates	11	12	13.5	12	15	14
18	Robert Johnsen	14.25	14	14.5	13.5	14.25	25
19	H. F. Watkins	a 10	10.95	12	10.23	14.99	14.99
21	Jno. G. Sessions	10.5	a 10.5	.....	10.5	14.9	14.5
23	L. C. Dulaney	11.98	17	21	14	b 14	18
24	McCadden & Roach	12.5	12.5	22.5	14.5	17.5	22.5
25	Bush Bros	14	16.5	18	12.5	15	25
27	P. H. Rogers	12	.....	14	13	.....	.....
28	Thomas & Co	13.99	13.99	13.99	13.99	13.99	.....
29	Ernest Hyner	13	11	13	11.5	25	20
30	J. E. Kerr	16.6	18.9	19.5	16.8	22.9	23
31	Martin Jennings & Co	13.5	14.75	14.75	12.75	16	16.5
33	Gilchrist & Crow	11.9	16	.....	11	.....	.....
34	Thompson & Powell	10.9	13.24	.....	13.75	.....	.....
35	J. H. McTighe	.....	12.5	a 12.5	11	.....	.....
36	J. B. Lewis	11.75	12.4	13.4	11.75	14.9	15.75
37	N. I. McLeod	12.23	12.97	.....	11.73	.....	.....
39	Batt. O'Brien	14	.....	.....	.....	.....	.....
40	John C. McIntyre	11.375	12.5	13.25	13.75	17.375	16.375
41	Helgason Bros	14	.....	.....	.....	.....	.....
42	Morrow & Carter	12	12	12	14	14	.....
43	Ben Talley	11	11	14	10.75	.....	.....

No.	Name of bidder.	Stations 811–900 (492 L.).	Stations 900–1000 (493 L.).	Stations 1000–1100 (494 L.).	Stations 1100–1200 (495 L.).	Stations 1200–1300 (497 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	J. H. Cary	26	14	12	11	18.5
2	John Scott & Sons	24.45	14.24	14.99	14.5	17
3	L. C. Dresbach & Bro	.....	.....	.....	14.75	.....
4	J. E. Moore	.....	16.45	.....	.....	10.94
5	Shippey & Kilpatrick	29	.....	.....	.....	.....
6	J. & A. Wynn	.....	13.625	12.375	10.9	12.75
8	M. McTighe	.....	.....	.....	13	13.25
10	T. Mike	.....	.....	13	a 9.5	a 9.99
11	Hugh Morgan	.....	.....	.....	.....	13.5
12	Green Clay	32	23	13.88	13.24	13.4
14	Aderholdt & Lowrance	24.75	16	15.75	13.75	13.75
15	C. A. Winter	24.875	17.74	14.125	10.75	11.125
17	W. M. Bates	23.75	17	15	12	12
18	Robert Johnsen	24.9	17	14	12.5	13
19	H. F. Watkins	27	13.49	15	10.95	11.99
20	Jno. A. Cannon	.....	.....	.....	11	14
21	Jno. G. Sessions	.....	.....	.....	.....	12.43
23	L. C. Dulaney	28	26	20	18	16
24	McCadden & Roach	30	18.95	14.15	12.24	12.95
25	Bush Bros	25	22.5	20	14	14
29	Ernest Hyner	21	16	14	11	11.75
30	J. E. Kerr	50	20	18.1	14.3	16.9
31	Martin Jennings & Co	24.75	14.625	12.375	11.875	13.625
32	W. R. Lewis & Co	.....	.....	13.4	.....	.....
33	Gilchrist & Crow	.....	15	15.25	12.5	14
34	Thompson & Powell	.....	.....	15	12.98	16
35	J. H. McTighe	.....	.....	.....	14.4	15.5
36	J. B. Lewis	24.75	a 13.25	a 11.9	11.4	12.9
37	N. I. McLeod	.....	.....	.....	10.7	11
39	Batt. O'Brien	.....	.....	14	14	13.5
40	John C. McIntyre	a 16.625	14.375	13.375	11.375	11.25
41	Helgason Bros	.....	.....	14	14	13
42	Morrow & Carter	.....	.....	16	13.45	17
43	Ben Talley	.....	.....	14	10.25	13

a Accepted. b Land side.

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Abstract of proposals for levee work in Lower Yazoo Levee district below Greenville, received and opened by Capt. H. C. Newcomer, etc.—Continued.

No.	Name of bidder.	Stations 1300–1400 (499 L.).	Stations 1400–1500 (500 L.).	Stations 1500–1600 (502 L.).	Stations 1600–1700 (503 L.).	Stations 1700–1800 (504 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	J. H. Cary	18.5	18.5	18.5	18.5	.....
2	John Scott & Sons	18.45	22	32	.....	.....
3	L. C. Dresbach & Bro	.....	.....	.....	.....	16.67
5	Shippey & Kilpatrick	.....	33	.....	.....	.....
6	J. & A. Wynn	16	12.875	.....	.....	14
8	M. McTighe	17	a 18	28	.....	.....
12	Green Clay	14.75	19	20	.....	.....
13	Bryan & King	.....	.....	.....	.....	13.75
14	Aderholdt & Lowrance	24.5	27.5	21	23	16.5
15	C. A. Winter	16.97	23.97	21	19.94	.....
17	W. M. Bates	25	27	25	22	14
18	Robert Johnsen	a 14	24.9	24.9	.....	.....
19	H. F. Watkins	29	30	27.25	27.25	a 11.48
20	Jno. A. Cannon	.....	.....	.....	.....	13.875
21	Jno. G. Sessions	23.9	29.72	.....	.....	19.9
23	L. C. Dulaney	28	30	22	40	36
24	McCadden & Roach	27.5	22.45	27.5	30	17.5
25	Bush Bros	25	28	30	30	16.5
29	Ernest Hyner	25	29	28	29	14.94
30	J. E. Kerr	45	50	50	.....	.....
31	Martin Jennings & Co	21.75	22.875	17.625	19.375	14.375
33	Gilchrist & Crow	.....	.....	.....	.....	15
35	J. H. McTighe	.....	34	.....	.....	.....
36	J. B. Lewis	19.7	23.7	17.7	16.7	12.5
39	Batt. O'Brien	19.74	.....	.....	.....	.....
40	John C. McIntyre	24.625	25.375	a 15.375	16.625	14.375
41	Helgason Bros	18	.....	.....	.....	.....
42	Morrow & Carter	26.9	27	22	.....	.....
43	Ben Talley	23.5	23.5	.....	a 14	13

No.	Name of bidder.	Stations 1800–1900 (505 L.).	Stations 1900–2000 (512 L.).	Stations 2000–2060 (513 L.).	Stations 2060–2110 (514 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*
2	John Scott & Sons	.....	.....	10.23	10.23
3	L. C. Dresbach & Bro	.....	.....	10.9	11.5
6	J. & A. Wynn	a 10	10.1	8.85	9.5
8	M. McTighe	14	13.5	12.15	12
10	T. Mike	.....	.....	11	.....
12	Green Clay	13.65	12.95	12.5	13
13	Bryan & King	12.5	13	.....	.....
14	Aderholdt & Lowrance	17	15	12	12.75
17	W. M. Bates	12.5	13	12	12.5
18	Robert Johnsen	14	13.5	11	11
19	H. F. Watkins	11.74	14.49	10.98	11.98
20	Jno. A. Cannon	14.875	21.875	12.375	13.5
21	Jno. G. Sessions	11.93	.....	10.9	11.42
22	W. J. Bentley & Co	.....	.....	23.45	22.45
23	L. C. Dulaney	18	18	12.25	12.25
24	McCadden & Roach	13.5	13.75	11	11
25	Bush Bros	15	15	11	11
26	Chas. T. Worthington	.....	14.75	a 9.875	.....
28	Thomas & Co	11.99	11.99	11.99	11.99
29	Ernest Hyner	12	12	.....	.....
30	J. E. Kerr	21.8	20	13.6	13.8
31	Martin Jennings & Co	14.875	a 11.875	11.375	11.375
33	Gilchrist & Crow	13	16	10	10.5
35	J. H. McTighe	.....	.....	12.4	12.4
36	J. B. Lewis	12.9	13.9	10.7	11.7
37	N. I. McLeod	.....	.....	10.23	10.73
39	Batt. O'Brien	.....	14.5	11	11.5
40	John C. McIntyre	13.375	13.375	10.375	10.625
41	Helgason Bros	.....	13.75	10.75	10.9
42	Morrow & Carter	.....	.....	13.5	13.9
43	Ben Talley	13.5	.....	10	a 10

a Accepted.

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Abstract of proposals for levee work in Upper Tensas Levee district, received and opened by Capt. H. C. Newcomer, Corps of Engineers, July 6, 1898.

No.	Name of bidder.	In Arkansas.					In Louisiana.		
		Stations 1780–1810 (466 L.).	Stations 1942–2047 (468 L.).	Stations 3400–3500 (505 L.).	Stations 3500–3600 (506 L.).	Stations 3600–3700 (506 L.).	Stations 2411–2500 (562 L.).	Stations 2810–2981 (574 L.).	Stations 2981–3081 (576 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
2	John Scott & Sons						18	18	21
4	J. E. Moore	13.375	16.625						
5	Shippey & Kilpatrick	14							
7	F. L. Maxwell						21.9	14	20.6
8	M. McTighe				19	20	16	12	19
9	L. Aschaffenburg						a 15.74	13.74	23.74
11	Hugh Morgan			17.5					
15	C. A. Winter			a 13.625	a 15				
16	C. A. Lacy	12.5	18.99						
17	W. M. Bates	15.94	20	13.98	17.5	17.5	19	12	33.33
18	Robert Johnsen	a 11.99					22.5		
20	Jno. A. Cannon			22.875	22.875	22.875			
21	Jno. G. Sessions							16.4	
22	W. J. Bentley & Co			21.75	21.75	21.75	19.75	18.6	a 18.6
24	McCadden & Roach	a 14.95		17.25	27.5	30			
28	Thomas & Co			17.99	17.99	17.99			
31	Martin Jennings & Co		22.875	17.625				13.625	21.875
32	W. R. Lewis & Co			14.4	14.4				
35	J. H. McTighe							a 9.99	
36	J. B. Lewis	16	21	15.2	21.7	24.7		14	19
38	Robert Nicholson						16.21		28
39	Batt. O'Brien			16			17.74	17.5	24
41	Helgason Bros						17.5	14.9	19.9
43	Ben Talley			15	15	a 15			

a Accepted.

Abstract of informal proposals for levee work in Lower Yazoo Levee district below Greenville, received and opened by Capt. H. C. Newcomer, Corps of Engineers, August 12, 1898.

No.	Name of bidder.	Stations 1070–1130 (495 L.).	Stations 2400–2571 (527 L.).	Stations 4078–4133 (554 L.).	Stations 4133–4188 (555 L.).	Stations 4188–4243 a (555 L.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Shippey & Kilpatrick			b 14.74	b 14.74	b 14.74
3	McCadden & Roach					12.49
5	J. E. Kerr	b 11.5	b 14	17	19	13
6	J. H. Bryan & Co	12	18			12
7	Helgason Bros			14.94	20	13.95
9	Cary & Johnsen			15.49	15.49	15.49
10	Thomas & Co			16	18	14
12	L. C. Dresbach & Bro					12.125
13	John Scott & Sons			17	17	17
14	Martin Jennings & Co	12.375	17	16	28	15
17	N. I. McLeod	12.48				12.375
18	W. M. Bates			15	22.5	12.5
19	Stone & Stansell		27	17	23	13
20	Ben Talley			14	16.44	11.95
23	L. C. Dulaney		16	16	24	11.98
30	Batt. O'Brien			19.98	27.73	14
31	C. A. Winter	9.375				
35	T. Likens	11.87	15.87			
37	Bush Bros			24	24	13.875

b Accepted.

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Abstract of informal proposals for levee work in Upper Tensas district, received and opened by Capt. H. C. Newcomer, Corps of Engineers, August 12, 1898.

No.	Name of bidder.	In Arkansas.								
		Stations 34–43 (426 R.).	Stations 520–605 (429 R.).	Stations 605–630 (430 R.).	Stations 710–750 (432 R.).	Stations 1200–1240 (442 R.).	Stations 1730–1740 (451 R.).	Stations 1826–1831 (466 R.).	Stations 2740–2850 (490 R.).	Stations 2850–3065 (494 R.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Shippey & Kilpatrick	20	20	20	20	17.43	17.43	a 17.43	17.43	17.43
3	McCadden & Roach	17.43	17.43	17.43	17.43	17.43	17.43	a 17.43	17.43	17.43
4	J. M. Whitehill	20	22	30	9.75	18.5				
5	J. E. Kerr								35	
8	M. McTighe								19.99	
9	Cary & Johnsen						b 17.49			
11	J. E. Moore								14.95	22.25
12	L. C. Dresbach & Bro.		b 17.98							
14	Martin Jennings & Co		25							
15	William M. Forrest		24.5	b 21	10	b 17.9				
18	W. M. Bates	25	18		12	25				20
19	Stone & Stansell		26.95						13	22.94
22	J. B. Lewis				14.625	19.625				
24	Andy Tracy	b 14.5			9.4					
25	C. A. Lacy	17		35	b 8.99	19.99				24.99
36	W. R. Lewis & Co								b 12.98	b 12.98
37	Bush Bros		32.5	32.75	20	22.5				

a Rejected and work readvertised. b Accepted.

Abstract of informal proposals for levee work in Upper Tensas Levee district, received and opened by Capt. H. C. Newcomer, Corps of Engineers, August 12, 1898.

No.	Name of bidder.	In Arkansas.			In Louisiana.				
		Stations 3100–3160 (498 R.).	Stations 3135–3400 (498 R.).	Stations 3700–3760 (509 R.).	Stations 2500–2601 (564 R.).	Stations 3031–3118 (577 R.).	Stations 3118–3197 (579 R.).	Stations 3197–3277 (580 R.).	Stations 3310–3328 (582 R.).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
2	A. S. Coltharp					a 9.95	17.45	a 11.45	9.94
3	McCadden & Roach	17.43	17.43	17.43					
5	J. E. Kerr				17	17		17	
6	J. H. Bryan & Co			13.99					
7	Helgason Bros				15.73	11.5	16.98	13	12
8	M. McTighe	18		15.25	15.75	14.75	19.5	15.5	15.74
11	J. E. Moore	16.75	27.5						
12	L. C. Dresbach & Bro.	13.73		13.73		13.23		13.43	
13	John Scott & Sons				16	16	16	16	16
14	Martin Jennings & Co	19			17.375	18	22	16	
16	J. H. McTighe					11.40	23.40	13.45	
18	W. M. Bates	a 11		a 12.5	a 14	12.5	a 17	13.75	
19	Stone & Stansell	13	a 24.94	13					
20	Ben Talley			15					
21	Ernest Hyner				18.94	12.44	18	13	
26	W. L. Linnan					12.98	27	15.98	
27	J. G. Boney								10.47
28	Hugh McCarten			16.7					
29	Robt. Nicholson				15.72	12.74			
30	Batt. O'Brien					13.73	25	13.98	14.73
32	W. J. Bentley & Co					14	19.8	16.5	17.4
33	L. Aschaffenburg				15.15	13.2		21.2	
34	F. L. Maxwell				26	12.6	28	26	21
37	Bush Bros					14.875	22.25	14.875	18
38	Geo. B. Vaughan					a 8.94			a 9.45

a Accepted.

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Abstract of informal proposals for levee work in Lower Yazoo Levee district, received and opened by Capt. H. C. Newcomer, Corps of Engineers, January 26, 1899.

No.	Name of bidder.	Baleshed Loop. Station 3169–3182 a (537 L.).	No.	Name of bidder.	Baleshed Loop. Station 3169–3182 a (537 L.).
		Cents.			*Cents.*
1	Robert Johnsen	[1] 15.7	6	T. Mike	16
2	Bush Bros.	18	7	Stone & Stansell	18.48
3	A. P. Chilton	15.75	8	J. H. Cary	16
4	H. Morgan	18.45	9	Ben Talley	19.9
5	John G. Sessions	19.22			

[1] Accepted.

List of assistant engineers employed on work of river and harbor improvement, in charge of Capt. H. C. Newcomer, Corps of Engineers, from June 30, 1898, to June 30, 1899, inclusive, under the acts approved June 4, 1897, July 19, 1897, and July 1, 1898.

Residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	Months.			
Arthur Hider, Greenville, Miss.	12	$250.00	Greenville, Miss	Care and repairs to plant, construction of towboat, and repairs to revetment works
E. C. Tollinger, Greenville, Miss.	2	175.00	do	Construction and repairs of levees in Upper Tensas district in Arkansas.
	10	200.00	do	Construction and repairs of levees in Upper Tensas district.
H. St. L. Coppée, Greenville, Miss.	2	175.00	do	Construction and repairs of levees in Lower Yazoo district below Greenville.
	10	200.00	do	Construction and repairs of levees in Lower Yazoo district.
J. D. Van Meter, Greenville, Miss.	2	150.00	do	Construction and repairs of levees in Lower Yazoo district above Greenville.
W. S. Brown, Lake Providence, La.	2	150.00	Lake Providence, La.	Construction and repairs of levees in Upper Tensas district in Louisiana.

List of contracts in force in the Lower Yazoo Levee district June 30, 1899, with names of contractors, date of approval, of beginning of work, and expiration.

Levee stations.	Miles below Cairo.	Contractor.	Date of approval.	Date of beginning work.	Expiration of contract.
200–300	483 L.	H. F. Watkins	Aug. 25, 1898	Sept. 5, 1898	Dec. 1, 1899
400–500	487 L.	J. H. McTighe	do	Dec. 12, 1898	Do.
700–790	492 L.	C. A. Winter	do	Dec. 8, 1898	Do.
811–900	492 L.	Jno. C. McIntyre	do	Aug. 6, 1898	Do.
900–1000	493 L.	J. B. Lewis	do	Sept. 1, 1898	Do.
1000–1100	494 L.	do	do	Nov. 16, 1898	Do.
1100–1200	495 L.	T. Mike	do	Oct. 22, 1898	Do.
1200–1300	497 L.	do	do	Oct. 1, 1898	Do.
1300–1400	499 L.	Robert Johnsen	do	Aug. 30, 1898	Do.
1400–1500	500 L.	M. McTighe	do	July 15, 1898	Do.
1500–1600	502 L.	Jno. C. McIntyre	do	Oct. 25, 1898	Do.
1600–1700	503 L.	Ben Talley	do	Aug. 1, 1898	Do.
1700–1800	504 L.	H. F. Watkins	do	Nov. 23, 1898	Do.
1800–1900	505 L.	J. & A. Wynn	do	Aug. 12, 1898	Do.

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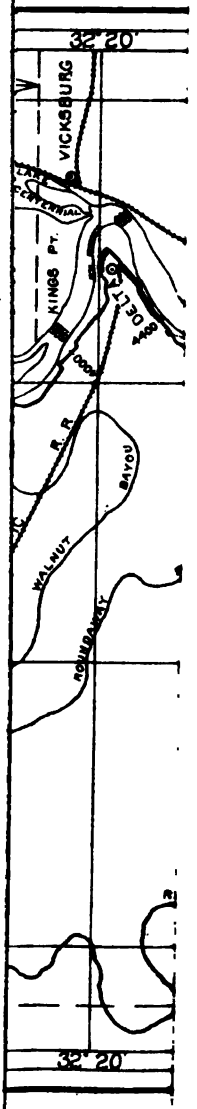

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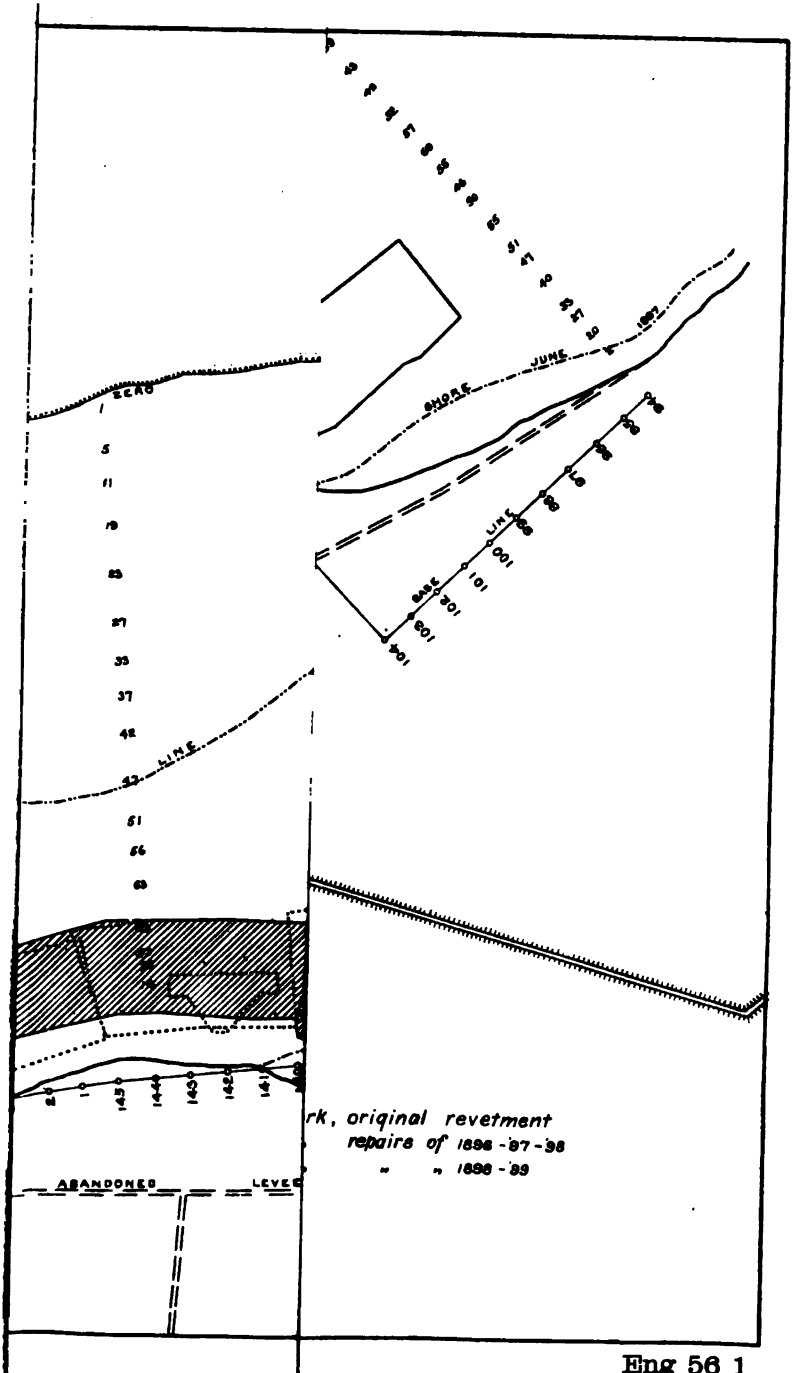

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List of contracts in force in the Upper Tensas Levee district June 30, 1899, with names of contractors, date of approval, of beginning work, and expiration.

Levee stations.	Miles below Cairo.	Contractor.	Date of approval.	Date of beginning work.	Expiration of contract.
1780–1810	466 R.	Robert Johnsen	Aug. 25, 1898	Sept. 10, 1898	Dec. 1, 1899
1942–2047	468 R.	McCadden & Roach	do	Aug. 29, 1898	Do.
3400–3500	505 R.	C. A. Winter	do	July 18, 1898	Do.
3500–3600	506 R.	do	do	Sept. 19, 1898	Do.
3600–3700	506 R.	Ben Talley	do	Dec. 12, 1898	Do.
2411–2500	562 R.	L. Aschaffenburg	do	Aug. 1, 1898	Do.
2810–2931	574 R.	J. H. McTighe	do	July 19, 1898	Do.
2931–3031	576 R.	W. J. Bentley & Co	do	Aug. 16, 1898	Do.

APPENDIX 4.

REPORT OF MAJOR G. McC. DERBY, CORPS OF ENGINEERS, ON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 1, 1899.

COLONEL: I have the honor to submit the following report upon the work of the Fourth district, Mississippi River Improvement, for the period from June 1, 1898, to June 1, 1899:

Pursuant to the requirements of Special Orders, No. 126, Adjutant-General's Office, 1898, I was relieved from duty in charge of this district by Maj. J. H. Willard, Corps of Engineers, U. S. A., June 3, 1898, and reported to Major-General Shafter, U. S. A., for duty as chief engineer of the Fifth Army Corps; Major Willard remained in charge of the district until November 30, 1898, when, in compliance with Special Orders, No. 267, Adjutant-General's Office, he was relieved by Capt. Henry Jervey, Corps of Engineers, U. S. A. After the close of the Santiago campaign and the declaration of peace with Spain, orders were issued mustering out the volunteer troops, and in compliance with Special Orders, No. 54, Adjutant-General's Office, current series, I returned to this district, relieving Captain Jervey March 23, 1899. These frequent changes of the officer in charge, the presence of yellow fever in the district, and the absence of several of the civil assistants who went to the war, have necessarily had an unfortunate effect upon the amount and cost of the work accomplished during the year.

The Fourth district, Mississippi River Improvement, extends from Warrenton, 7¼ miles below Vicksburg, to the Head of the Passes, about 13 miles from the Gulf of Mexico, a distance of 452.8 miles by river.

The works include the improvement of the harbors at Natchez and Vidalia, Mississippi and Louisiana; improvements at the junction of the Mississippi, Red, and Atchafalaya rivers; improvement of the harbor at New Orleans, La.; improvement of the bars in the Mississippi River below Natchez, and the construction, repair, and maintenance of a portion of the levee system of the district.

HARBORS OF NATCHEZ AND VIDALIA.

The project for this work contemplates the construction of a levee on or near the axis of Cowpen Neck, to prevent the flow of water across the neck during high stages of the river, and the construction of about 16,000 linear feet of bank revetment in Giles Bend; estimated cost, $541,300. The object of the proposed work is to prevent the formation of a threatened cut-off at Cowpen Neck, which would cause the destruction of the town of Vidalia, much injury to the water front and landings at Natchez, and increased cavings of the banks for many miles above and below, with consequent destruction of expensive parts of the levee system.

The amount expended upon this project to June 30, 1898, was $210,307.74, and there remained available a balance of $131,944.30.

During the current year but little progress was made; the river remained so high throughout the season as to greatly interfere with the work, and the presence of yellow fever at New Orleans and Natchez, and elsewhere along the lower river, made it impracticable to secure the necessary labor to do the work, and quarantine restrictions prevented the contractors from delivering rock. It was not until September 8 that it was thought advisable to commence the construction of mats and cribs. This was continued, in the face of extraordinary difficulties, until January 18, when it was suspended on account of the rising river; 122,000 square feet of

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mats and 52,800 cubic feet of cribs were constructed and towed from the willow bar at L'Argent to the bank to be protected, a distance of about 10 miles. The details of the work accomplished are fully described in the appended report of my assistant, Mr. H. S. Douglas. A sketch is herewith showing the location of the spurs and the rate of caving of the bank.

In discussing this work in my annual report last year I reported the situation as follows:

"The interval between the axes of the spurs is about 450 feet, and experience may prove that this interval is too wide; but even if an extra spur has to be placed in each interval, the first cost of the work will still compare favorably with other revetment work on the river.

"Thorough and frequent inspection is an essential to the success of this revetment, as, for that matter, I believe it to be for any revetment. Repairs which can be effected at nominal cost when the necessity first arises may cost as much as a new revetment if neglected for a few months.

"If the Giles Bend revetment fails it will probably be from one of two causes—the continuance of caving between the spurs, due to eddy action, or the deepening of the channel of the river along a line connecting the outer ends of the spurs. In the first case the spurs may be overthrown laterally or the river may get in between them and the shore. In the second case the spurs may be destroyed by being undermined from the outer end inward.

"Both of these threatened dangers have their appropriate remedy if the trouble is detected early enough. Eddy action between the spurs can be broken up by placing an additional spur between the original ones; and, in my judgment, such additional spurs should be made with openings through them, to carry out the principle of reducing the velocity of the water in contact with the bank by obstructing the flow, while avoiding obstructing it so much as to reverse the direction of the current.

"If the river scours its bed in front of the line of spurs so as to threaten undermining the ends of them it is evident that the new subaqueous bank so formed must be protected the same as the original bank by prolonging the spurs until their outer ends rest upon the horizontal bed of the river."

The condition of the revetment in Giles Bend now appears to be precarious. On account of the high stage of the river no hydrographic survey has been made since last December, and the soundings taken then extend only from Spur 8 to Spur 12, inclusive. These soundings show that the bank and bed of the river have continued to scour between the spurs, the deepening being generally about 30 feet, and more in deep water than near shore, so that the bank is decidedly steeper than it was originally. No recession of the low-water line is shown at the spurs, but between them it has receded from 25 to 100 feet. The shore end of Spur 8 seems to have been destroyed.

It is most unfortunate that this situation was not dealt with last season. The failure to make a survey immediately after high water last summer and at once proceed with the necessary repairs, for which there were ample funds available, appears to have been due to the frequency with which the work changed hands last season and to the prevalence of yellow fever along the lower river, which made it almost impracticable to do any work on account of the scarcity of labor.

If the work could have been done last season I believe the revetment could readily have been made secure at very moderate expense by simply constructing an additional spur, with its pile-dike shore connection, in the middle of each interval between the existing spurs. This would only have brought the total cost of the revetment up to $19.04 per foot, which is still very low compared with the cost of continuous revetment.

Instead of doing this, however, all of the pile-dike shore connections were removed and practically no work done below low water.

The pile-dike shore connection was an attempt to hold the bank between high and low water on the spur-dike principle, and I know no more promising type of dike for this purpose. The abandonment of the spur-dike principle between high and low water apparently makes it necessary to protect this portion of the bank with a continuous pavement of rock or brick, and this in turn necessitates the abandonment of any attempt to repair the existing revetment on the spur-dike principle, because under the most favorable conditions there is likely to be some caving between spurs, and even a very little would undermine and destroy a continuous paving of stone or brick. A continuous revetment above low water seems to necessitate a continuous revetment below low water.

It is therefore proposed the coming season to make a survey as soon as the stage of the river will permit, and if there has been no radical change in the situation since the survey of last December, to proceed with the necessary repairs as rapidly as possible on the following system: Where the low-water line has receded behind the spur so as to impair its connection with shore, the mat and spur will be prolonged inward so as to reestablish the connection between the spur and shore; the interval between the foundation mats of the spurs being about 300 feet, two 150-foot mats

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will be laid so as to nearly or quite cover the whole of the unprotected bank below low water; the inshore ends of the mats will be located several feet above low-water mark, and the mats will be 300 feet long, so that no attempt will be made to bring their outer ends into alignment with the foundation mats of the spurs. Spurs 1 and 2 are in deep pockets, and apparently the additional mats are not yet needed in the intervals adjoining them. Above low water the Mississippi River Commission have decided to pave the bank with rock or brick as fast as the river grades it back to a slope of about 1 on 3.

It is probable that the levee on Cowpen Neck will be breached by the caving bank before or during the next high water. When this takes place it is probable that the whole levee would be rapidly washed away if nothing is done to prevent it. It is proposed to expend about $600 in constructing a new head for the levee at some point on the line where it will have a probable life of three years or more; the stone now on the outer end of the levee will be used to revet the new head.

In this connection it should be observed that the revetment work in Giles Bend has not yet reached the narrowest part of Cowpen Neck, and that a further appropriation is needed to prolong the revetment past this narrow part of the Neck, as, until this is done, the money already allotted will have produced no useful fruit.

The amount expended from June 30, 1898, to June 30, 1899, is $21,944.30, distributed as follows:

Office expenses (main office)		$723.31
Other administrative expenses		1,705.39
Construction of revetment (hired labor):		
Materials	$3,161.59	
Wages	6,934.59	
Subsistence	4,243.25	
		14,339.43
Surveys		508.69
Repairs to plant		491.61
Care of plant		782.96
New plant		3,387.26
Miscellaneous		5.65
Total		21,944.30

Money statement.

IMPROVING HARBORS AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

July 1, 1898, balance unexpended	[1]$21,944.30
Amount appropriated by river and harbor act of March 3, 1899	50,000.00
	71,944.30
June 30, 1899, amount expended during fiscal year	21,944.30
July 1, 1899, balance unexpended	50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	80,000.00

The amount expended from June 30, 1898, to June 30, 1899, is $36,726.78, distributed as follows:

Office expenses (main office)		$1,842.31
Other administrative expenses		4,321.10
Construction of revetment (hired labor):		
Materials	$21,077.85	
Wages	4,057.75	
Subsistence	3,077.55	
		28,213.15
Surveys		15.33
Repairs to plant		426.39
Care of plant		1,866.10
New plant		31.90
Miscellaneous		10.50
Total		36,726.78

[1] Balance unexpended July 1, 1898, as stated in previous report, $131,944.30. In this amount was included $110,000 which was allotted from the appropriation for improving Mississippi River for Giles Bend. A separate financial statement for Giles Bend is submitted.

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Money statement.

PREVENTION OF CUT-OFF AT GILES BEND, LA.

June 26, 1897, amount allotted from sundry civil act, approved June 4, 1897		$110,000.00
June 30, 1899, amount expended during fiscal year		36,726.78
July 1, 1899, balance unexpended		73,273.22
July 1, 1899, outstanding liabilities	$1,122.37	
July 1, 1899, amount covered by uncompleted contracts	5,410.23	
		6,532.60
July 1, 1899, balance available		66,740.62

JUNCTION OF THE MISSISSIPPI, RED, AND ATCHAFALAYA RIVERS, LOUISIANA.

A detailed description of the difficulties in this vicinity, which the improvements are designed to rectify, will be found in the annual report for 1892. In general terms these difficulties consist in the silting up of Old River, the only navigable connection between the Mississippi and the Red and Atchafalaya rivers.

The works heretofore contemplated had in view the following objects:

To check the enlargement of the Atchafalaya and limit its outlet capacity by a system of low relief dams or sills.

To separate the Red from the Atchafalaya during the low water, and up to a 10-foot stage, by means of a low dam at the West end of Turnbull Island, which would deflect the Red around the upper side of the island.

To supply a new outlet for the Red by cutting a canal across Carrs Point and obstructing the lower end of Upper Old River.

The Red would thus always be a tributary of the Mississippi at low stages and the Atchafalaya an outlet, while the conditions at high stage would remain about the same as they were originally.

The plan also contemplated maintaining low-water navigation through Lower Old River, if practicable, by dredging or otherwise, pending the completion of the above system of works.

Owing to insufficient funds, works on all parts of this project, except the first and last, has been suspended for many years; and experience having demonstrated that the channel in Lower Old River can be kept open with the dredge at moderate expense, even after having been exposed to the effects of extreme high water, it is understood that the improvement of the channel of Upper Old River has been definitely abandoned, narrowing the project to preventing the undue enlargement of the Atchafalaya and the maintenance of a navigable channel through Lower Old River.

The usual annual examination was made around the sill dams in December. The high water of 1898 not having been an extreme one, and the current at ordinary stages having been principally from the Mississippi into the Atchafalaya, the survey shows but little scouring around the dams this year, and on the contrary a considerable deposit of sand above, below, and between the dams, amounting, however, to much less than the deposit which had taken place before the flood of 1897.

As experience has shown that a single extraordinary high water, like 1897, will remove all this deposit and continue the attack on the original bed of the river above and below the dams, it would appear to be necessary to widen the foundation mats above and below each dam. This work will be undertaken next season if the plant can be spared from more urgent work.

Owing to the unusual height of the low-water stage of the Mississippi during the season but little dredging became necessary in Old River. It is estimated that 73,800 cubic yards of material were dredged and deposited in the stream alongside the cut made by the dredge. The dredge *Ram* was kept in Old River from August 11 to November 17, but only worked forty-four days.

In compliance with a resolution of the Mississippi River Commission a survey was made from Simmsport to Red River Landing, repeating the cross sections sounded in 1894. The mean of 112 cross sections between Barbres and the Mississippi River shows that below 35 feet on Barbres gauge the cross section of Old River has increased as follows: Area, from 20,901 square feet in 1894 to 21,843 square feet in 1899; depth, from 26.6 linear feet in 1894 to 30.8 linear feet in 1899. The width has decreased from 793 linear feet in 1894 to 717 linear feet in 1899.

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The amount expended from June 30, 1898, to June 30, 1899, is $15,025.02, distributed as follows:

Office expenses		$2,404.80
Other administrative expenses		925.39
Dredging Old River (hired labor):		
Materials	$470.94	
Wages	2,950.30	
Subsistence	929.70	
		4,350.94
Surveys		3,163.93
Repairs to plant		471.10
Care of plant		2,023.12
New plant		1,685.74
Total		15,025.02

Money statement.

IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

July 1, 1898, balance unexpended		$67,337.87
Amount appropriated by river and harbor act of March 3, 1899		25,000.00
		92,337.87
June 30, 1899, amount expended during fiscal year		15,025.02
July 1, 1899, balance unexpended		77,312.85
July 1, 1899, outstanding liabilities	$65.87	
July 1, 1899, amount covered by uncompleted contracts	19,000.00	
		19,065.87
July 1, 1899, balance available		58,246.98

NEW ORLEANS HARBOR.

The approved project for the improvement of New Orleans Harbor contemplates the protection of the banks in all of the caving bends, by means of sloping submerged spur dikes, made mostly of brush and stone, resting upon wide foot mats, and spaced at intervals varying from 400 to 1,600 feet as circumstances may require, with continuous brush and stone revetment covering the intervals where necessary. The ultimate cost is not estimated.

At the close of the last working season the work completed comprised about 400 feet of mattress protection at the head of Carrollton Bend; five spur dikes, with continuous revetment covering the intervals, in Carrollton Bend; two spur dikes in the Greenville Bend; six spur dikes in the Gouldsboro Bend; in the Third District Reach sixteen spur dikes had been completed, a continuous revetment constructed between Spurs 1 and 2, and a mattress 150 by 200 feet placed contiguous to the foundation mattress of Spurs 2′, 3′, 3½′, 4′, and 4½′.

The funds available June 30, 1898, amounted to $90,536.60 and a project had been approved for the application of these funds at and above Algiers Point. Work was not begun under this project until August 20, the unusual height of the river preventing an earlier beginning.

But little progress was made before the work was interrupted by the appearance of yellow fever at New Orleans, making it impracticable to secure labor and uninterrupted transportation on the river. Work was resumed November 4 when the yellow fever situation had somewhat improved, but it was again interrupted by high water January 18.

Spurs 12 to 17 inclusive, on the bank between Gouldsboro and Algiers Point were completed during the season, with additional buttresses below Spurs 12 and 16. These spurs are shown on the sketch herewith.

At its meeting in December the Mississippi River Commission transferred $12,000 of the allotment previously made for Algiers Point to the protection of the bank around the elevator and wharf at Southport. Under this allotment a mat was laid along the front of the wharf and against its lower end, as shown on the accompanying sketch. To complete the project it will still be necessary to cover the bed of the river with mattress work underneath the wharf

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The total amount of work done in New Orleans Harbor this year consists of 472,500 square feet of mats and 586,800 cubic feet of cribs. The cost of the work was 7.7 cents per square foot for mats and 3.8 cents per cubic foot for cribs. This cost is unusually high, but the difficulties encountered this season through the prevalence of yellow fever and the unusual height of the river during the low water season have been extraordinary.

For further details connected with the work reference is made to the accompanying report of Mr. H. S. Douglas, assistant engineer.

During the past year there has been serious caving of the bank within the harbor of New Orleans, both at Southport and in the Third District Reach. Surveys are now in progress to show the extent of the damage done. It is probable that extensive revetment work will be necessary at Southport, but in the Third District Reach it does not now seem to be practicable to undertake any work as the Orleans levee board have, with the sanction of the Secretary of War, constructed certain works along the river bank which would jeopardize any work the Government might do.

The amount expended from June 30, 1898, to June 30, 1899, is $75,736.23, distributed as follows:

Office expenses (main office)		$3,401.90
Other administrative expenses		6,109.03
Construction (hired labor):		
Materials	$18,594.68	
Wages	29,999.29	
Subsistence	11,900.42	
		60,494.39
Surveys		1,843.43
Repairs to plant		405.64
Care of plant		2,101.10
New plant		1,349.34
Miscellaneous		31.40
Total		75,736.23

Money statement.

IMPROVING HARBOR AT NEW ORLEANS, LA.

July 1, 1898, balance unexpended		$101,251.86
Amount appropriated by river and harbor act of March 3, 1899		110,000.00
		211,251.86
June 30, 1899, amount expended during fiscal year		75,736.23
July 1, 1899, balance unexpended		135,515.63
July 1, 1899, outstanding liabilities	$47.50	
July 1, 1899, amount covered by uncompleted contracts	5,000.00	
		5,047.50
July 1, 1899, balance available		130,468.13
Amount that can be profitably expended in fiscal year ending June 30, 1900		300,000.00

DREDGING BARS BELOW NATCHEZ.

The bars in the Mississippi River at Natchez Island, Fords, Torras, and Tunica caused no difficulty to navigation during low water this season, as the river never fell below 12.6 on the Natchez gauge. No dredging was necessary and none was done.

PLANT.

All of the plant of the district is in good condition; but few repairs were made last year, and much work of this character will be necessary in the early future.

The towboat *Osceola*, and barges 542 and 546, having decayed beyond the point of economical repair, they were condemned and disposed of during the year. Barges Nos. 16 and 28 were transferred to the Quartermaster's Department during the Spanish war and two others are now building to replace them. The new steel towboat

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Gen. John Newton, built to replace the *Osceola*, has been delivered by the contractors but has not yet been finally accepted.

The plant of the Fourth district has always been comparatively small, having been constructed and maintained from the appropriations made from time to time for the two harbors in the district and the Red and Atchafalaya rivers.

It has heretofore been adequate for the purposes because the above appropriations have been quite small and irregular, and, until very recently, it has never been necessary to do extensive work at more than one of the above-mentioned points at a time. Very recently, by improvements in methods, the working capacity of the plant has been nearly doubled, so that with comparatively slight additions it can now be made ample for extensive revetment work at two different localities.

During the coming season there will be important bank revetment work to be done at Giles Bend, Kempe Bend, the head of the Atchafalaya, New Orleans Harbor, and perhaps at Bondurant Chute, which will necessitate increasing the plant by ten barges and a tugboat. A hydraulic grader will also be necessary, but there is a possibility that one may be borrowed from the Third district.

The report of Mr. H. S. Douglas, assistant engineer, in the care and maintenance of the plant, is herewith.

The amount expended from June 30, 1898, to June 30, 1899, is $18,079.15, distributed as follows:

Office expenses (main office)		
Other administrative expenses		$3,053.67
New plant		5,799.58
Repairs (hired labor):		
Materials	$3,394.74	
Wages	3,974.93	
Subsistence	115.60	
		7,485.27
Care of plant		1,642.67
Miscellaneous		97.96
Total		18,079.15

Money statement.

PLANT.

July 1, 1898, balance unexpended		$18,191.88
September 21, 1898, amount transferred from Quartermaster's Department, U. S. A		8,000.00
March 19, 1899, amount allotted from appropriation sundry civil act July 1, 1898		5,556.00
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899		64,444.00
		96,191.88
June 30, 1899, amount expended during fiscal year		18,079.15
July 1, 1899, balance unexpended		78,112.73
July 1, 1899, outstanding liabilities	$512.62	
Amount covered by uncompleted contracts	8,283.50	
		8,796.12
July 1, 1899, balance available		69,316.61

SURVEYS, GAUGES, AND OBSERVATIONS.

Surveys have been made at Algiers Point, Southport, Gouldsboro, the Third district Reach, Giles Bend, and from Simmsport to Red River Landing.

The gauge at Barbres Landing, at the junction of the Red and Atchafalaya rivers, has been maintained as heretofore.

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The amount expended from June 30, 1898, to June 30, 1899, is $2,959.62, distributed as follows:

Office expenses (main office)		$151.83
Other administrative expenses		153.13
Field work and drafting:		
Materials	$15.18	
Wages	2,307.01	
Subsistence	186.25	
		2,508.44
Repairs to plant		3.50
Care of plant		.92
New plant		141.80
Total		2,959.62

Money statement.

SURVEYS, GAUGES, AND OBSERVATIONS.

July 1, 1898, balance unexpended	$2,959.62
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899	5,000.00
	7,959.62
June 30, 1899, amount expended during fiscal year	2,959.62
July 1, 1899, balance unexpended	5,000.00

LEVEES.

For work connected with levee construction and maintenance the district is subdivided into seven levee districts, as follows:

The Lower Tensas Levee district, right bank, which extends from the upper limits of the Fourth district, opposite Warrenton, to the mouth of Red River. In this district the levee system is continuous from the upper end to a point 5 miles below Fairview Landing, 131.5 miles by river, leaving about 26 miles unprotected.

The Atchafalaya Levee district, right bank, which extends from the mouth of Red River to the head of Bayou Lafourche, a distance of 122 miles by river. The levee system is continuous in this district.

The Lafourche Levee district, right bank, which extends from the head of Bayou Lafourche to New Orleans. The distance by river is 78 miles, and the levee system is continuous.

The Barataria Levee district, right bank, which extends from New Orleans to the Head of the Passes, 82½ miles. The levee system is continuous down to the Jump, 71.5 miles.

The Homochitto Levee district, left bank, created by a resolution of the Mississippi River Commission November 19, 1894, which extends from the mouth of the Yazoo River to Baton Rouge, 238.5 miles by river. There are as yet no levees in this district, except a few detached lengths built by private parties.

The Pontchartrain Levee district, left bank, which extends from Baton Rouge to New Orleans, 123.5 miles. The levees are continuous.

The Lake Borgne Levee district, left bank, which extends from New Orleans to the Head of the Passes, 91 miles. The levee system at present only extends to Fort St. Philip, covering 70 miles of the river.

Attention is invited to the accompanying report of Mr. W. J. Hardee, assistant engineer. Mr. William Starling was in charge of the levee work of the district from August 17, 1898, until March 31, 1899, during the absence of Mr. Hardee, who served in the Volunteer Army during the Spanish war.

The funds available for levee construction in this district June 30, 1898, amounted to $403,412.09. This amount was subsequently increased to $880,062.09 by the allotments made from the appropriation of March 3, 1899.

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The construction and maintenance of an effective levee system is an undertaking of such vast magnitude that it is only financially practicable on condition of great economy in the expenditure of the available funds. The following table shows how the cost of levee building has varied in this district during recent years:

Contracts.

Year.	Cubic yardage.	Cost per cubic yard.
		Cents.
1890	895,000	19.3
1891	1,410,000	21.2
1892	908,000	17.8
1893	2,142,000	21.2
1894	3,589,000	15
1895	3,414,000	12.3
1896	4,658,000	10.3
1897	1,775,000	10.99
1898	3,392,000	14.12
1899	2,465,000	13.6

The past year has been an unfavorable one for levee building, the summer months having been unusually rainy, and the presence of yellow fever along the river having greatly increased the difficulty of getting labor and supplies.

Efforts toward the introduction of machinery for levee building have been continued during the year, and three different contracts were made for work to be done with dredges. Two of these contracts have been fairly successful, but the machinery used on the third was quite inadequate, and the contractors abandoned the work after several expensive failures.

The highest gauge reading reached by the river this year was 47.3 at Vicksburg; but little high-water protection work has been necessary, so that it has been possible to save nearly all of the funds reserved for high-water emergencies. On the other hand, the unusually high stage of the river during the low-water season has caused extraordinary caving of the banks in many localities, necessitating the construction of new levees.

The following table shows approximately the condition of the levee line on the completion of this year's contracts:

Levee districts.

	Lower Tensas.	Atchafalaya.	Lafourche.	Pontchartrain.	Barataria.	Lake Borgne.
Above high water of 1897—	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Less than 1 foot	13	7.29	.....	21.50	8.60	24.05
From 1 to 2 feet	22.50	18.19	9.30	50	23.09	15.64
From 2 to 3 feet	20	25.58	21.76	29	24.65	15
More than 3 feet	70.61	77.12	51	25.16	14.05	16.98
Total	126.11	128.18	82.06	125.66	70.39	71.67

The banquettes called for by the standard cross section have as yet only been constructed in a few of the most urgent cases.

No work has been done in the Homochitto Levee district, there having been no funds available.

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The details of the work accomplished during the year in the other districts are given in the following tables:

Fourth district levees, 1898–99.

LOWER TENSAS LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
	Panola:						
1	Section 1.....	646	R.	Herman F. Garbish.....	3,116	2,400	3
2	Section 2.....	646	R.	.....do.....	2,313	1,600	3
3	Section 5.....	647	R.	J. G. Boney.....	1,900	1,500	3
4	Section 6.....	647	R.	.....do.....	1,500	1,300	3
	Duckpond:						
5	Section 3.....	650	R.	C. E. Ponder.....	2,889	2,500	3
6	Section 4.....	650	R.	.....do.....	2,441	1,400	3
7	Kempe.....	657	R.	Helgason Bros.....	2,613	2,610	1
	Stockbridge:						
8	Section 5.....	659	R.	Clark & Reagan.....	2,023	2,023	3
9	Section 6.....	661	R.	James R. Marlow.....	1,382	1,300	3
10	Section 7.....	661	R.	.....do.....	1,200	1,200	3
11	Section 8.....	661	R.	.....do.....	1,200	1,200	3
12	Section 9.....	661	R.	.....do.....	1,127	1,100	3
	Waterproof:						
13	Section 1.....	662	R.	.....do.....	2,200	2,200	3
14	Section 2.....	662	R.	.....do.....	1,900	1,900	3
15	Section 3.....	662	R.	.....do.....	1,900	1,500	3
16	Section 4.....	662	R.	.....do.....	2,000	2,000	3
	L'Argent:						
17	Section 1.....	663	R.	John Scott & Sons.....	401	400	5.4
18	Section 2.....	663	R.	.....do.....	500	500	5.4
19	Section 3.....	663	R.	.....do.....	400	400	5.4
20	Section 4.....	663	R.	.....do.....	400	400	5.4
21	Section 5.....	663	R.	.....do.....	300	300	5.4
22	Section 6.....	663	R.	.....do.....	400	400	5.4
23	Section 7.....	663	R.	.....do.....	350	350	5.4
24	Section 8.....	664	R.	.....do.....	250	250	5.4
25	Section 9.....	664	R.	.....do.....	300	300	5.4
26	Section 10.....	664	R.	.....do.....	300	300	5.4
27	Section 11.....	664	R.	.....do.....	300	300	5.4
28	Section 12.....	664	R.	.....do.....	300	300	5.4
29	Section 13.....	664	R.	.....do.....	300	300	5.4
30	Section 14.....	664	R.	.....do.....	300	300	5.4
31	Section 15.....	664	R.	.....do.....	300	300	5.4
32	Section 16.....	665	R.	.....do.....	300	300	5.4
33	Section 17.....	665	R.	.....do.....	250	250	5.4
34	Section 18.....	665	R.	.....do.....	250	250	5.4
35	Section 19.....	665	R.	.....do.....	300	300	5.4
36	Section 20.....	665	R.	.....do.....	350	350	5.4
37	Section 21.....	665	R.	.....do.....	450	450	5.4
38	Section 22.....	665	R.	.....do.....	400	400	5.4
39	Section 23.....	665	R.	.....do.....	400	400	5.4
40	Section 24.....	665	R.	.....do.....	513	513	5.4
	Delhi:						
41	Section 5.....	680	R.	Helgason Bros.....	800	600	5.3
42	Section 6.....	680	R.	.....do.....	700	600	5.3
43	Section 9.....	680	R.	.....do.....	800	600	5.3
44	Section 10.....	680	R.	.....do.....	800	600	5.3
45	Section 11.....	680	R.	.....do.....	900	700	5.3
46	Section 13.....	680	R.	.....do.....	900	700	5.3
47	Section 14.....	680	R.	.....do.....	900	700	5.3
48	Section 15.....	680	R.	.....do.....	776	600	5.3
49	Rifle Point, section 1.	689	R.	Manning & Gibson.....	4,181	4,200	3.4
	Esperanza:						
50	Section 6.....	715	R.	Batt O'Brien.....	900	1,200	5.7
51	Section 10.....	715	R.	.....do.....	1,000	1,300	5.7
52	Section 13.....	715	R.	C. O'Donnell & Co.....	900	1,400	5.7
53	Section 15.....	715	R.	.....do.....	1,300	1,900	5.7
	Ashley:						
54	Section 2.....	724	R.	John Scott & Sons.....	1,100	1,000	3
55	Section 3.....	724	R.	.....do.....	1,200	1,200	3
56	Section 12.....	724	R.	.....do.....	1,100	400	3
57	Section 13.....	724	R.	.....do.....	1,451	700	3
58	Ashley to Fairview, section 6.	725	R.	D. P. Lyles.....	3,000	2,700	3

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Fourth district levees, 1898-99—Continued.

LOWER TENSAS LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
	Panola:	*Feet.*				*Feet.*	*Feet.*	1898.	1898.
1	Section 1.....	8	3 to 1	3 to 1	Enlargement .	0.8	14	July 23	Oct. 7
2	Section 2.....	8	3 to 1	3 to 1	.....do	1.8	14.1	....do ...	Oct. 29
3	Section 5.....	8	3 to 1	3 to 1	.....do	1.3	13.3	....do ...	Dec. 27
4	Section 6.....	8	3 to 1	3 to 1	.....do	1.6	14.3	....do ...	Oct. 3
	Duckpond:								
5	Section 3.....	8	3 to 1	3 to 1	.....do	1.3	13.3	....do ...	Nov. 6
6	Section 4.....	8	3 to 1	3 to 1	.....do	1.4	12.7	....do ...	Sept. 8 1899.
7	Kempe.....	8	3 to 1	3 to 1	New.....	.....	19.7	Sept. 10	Mar. 21 1898.
	Stockbridge:								
8	Section 5.....	8	3 to 1	3 to 1	Enlargement .	2.2	14.5	July 23	Dec. 19
9	Section 6.....	8	3 to 1	3 to 1	.....do	2.3	12.3	....do ...	Sept. 27
10	Section 7.....	8	3 to 1	3 to 1	.....do	2.4	11.4	....do ...	Nov. 3 1899.
11	Section 8.....	8	3 to 1	3 to 1	.....do	2.5	11.4	....do ...	Mar. 10
12	Section 9.....	8	3 to 1	3 to 1	.....do	2.4	12.3	....do ...	Feb. 21
	Waterproof:								
13	Section 1.....	8	3 to 1	3 to 1	.....do	2.3	11.2	....do ...	Mar. 8
14	Section 2.....	8	3 to 1	3 to 1	.....do	2.7	12.6	....do ...	Mar. 31 1898.
15	Section 3.....	8	3 to 1	3 to 1	.....do	2.7	12.6	....do ...	Sept. 29 1899.
16	Section 4.....	8	3 to 1	3 to 1	.....do	2.6	12.7	....do ... 1897.	Mar. 17 1898.
	L'Argent:								
17	Section 1.....	8	3 to 1	3 to 1	New.....	.....	17.1	Sept. 27	Nov. 12
18	Section 2.....	8	3 to 1	3 to 1	.....do	.....	16.5	....do ...	Do.
19	Section 3.....	8	3 to 1	3 to 1	.....do	.....	17.4	....do ...	Do.
20	Section 4.....	8	3 to 1	3 to 1	.....do	.....	17.6	....do ...	Do.
21	Section 5.....	8	3 to 1	3 to 1	.....do	.....	18.3	....do ...	Do.
22	Section 6.....	8	3 to 1	3 to 1	.....do	.....	17.7	....do ...	Do.
23	Section 7.....	8	3 to 1	3 to 1	.....do	.....	19.3	....do ...	Do.
24	Section 8.....	8	3 to 1	3 to 1	.....do	.....	19.4	....do ...	Do.
25	Section 9.....	8	3 to 1	3 to 1	.....do	.....	20.2	....do ...	Do.
26	Section 10.....	8	3 to 1	3 to 1	.....do	.....	20.8	....do ...	Do.
27	Section 11.....	8	3 to 1	3 to 1	.....do	.....	21	....do ...	Do.
28	Section 12.....	8	3 to 1	3 to 1	.....do	.....	20.8	....do ...	Do.
29	Section 13.....	8	3 to 1	3 to 1	.....do	.....	21.6	....do ...	Do.
30	Section 14.....	8	3 to 1	3 to 1	.....do	.....	21.6	....do ...	Do.
31	Section 15.....	8	3 to 1	3 to 1	.....do	.....	21.3	....do ...	Do.
32	Section 16.....	8	3 to 1	3 to 1	.....do	.....	20.7	....do ...	Do.
33	Section 17.....	8	3 to 1	3 to 1	.....do	.....	20.8	....do ...	Do.
34	Section 18.....	8	3 to 1	3 to 1	.....do	.....	23	....do ...	Do.
35	Section 19.....	8	3 to 1	3 to 1	.....do	.....	18.4	....do ...	Do.
36	Section 20.....	8	3 to 1	3 to 1	.....do	.....	17.4	....do ...	Do.
37	Section 21.....	8	3 to 1	3 to 1	.....do	.....	16.6	....do ...	Do.
38	Section 22.....	8	3 to 1	3 to 1	.....do	.....	17.3	....do ...	Do.
39	Section 23.....	8	3 to 1	3 to 1	.....do	.....	17.5	....do ...	Do.
40	Section 24.....	8	3 to 1	3 to 1	.....do	.....	16.2	....do ...	Do.
	Delhi:								
41	Section 5.....	8	3 to 1	3 to 1	Enlargement .	4.4	16.4	....do ...	June 28
42	Section 6.....	8	3 to 1	3 to 1	.....do	4.8	17.3	....do ...	Do.
43	Section 9.....	8	3 to 1	3 to 1	.....do	4.7	17.3	....do ...	July 25
44	Section 10.....	8	3 to 1	3 to 1	.....do	3.8	17.3	....do ...	June 28
45	Section 11.....	8	3 to 1	3 to 1	.....do	3.9	17.6	....do ...	June 6
46	Section 13.....	8	3 to 1	3 to 1	.....do	4.2	15.6	....do ...	Aug. 2
47	Section 14.....	8	3 to 1	3 to 1	.....do	4.3	13.3	....do ...	Do.
48	Section 15.....	8	3 to 1	3 to 1	.....do	4.5	12.7	....do ... 1896.	Do.
49	Rifle Point, section 1.	8	3 to 1	3 to 1	.....do	2.2	9.7	Oct. 15	Sept. 24
	Esperanza:							1897.	
50	Section 6.....	8	3 to 1	3 to 1	.....do	5.3	17.3	Dec. 10	Aug. 31
51	Section 10.....	8	3 to 1	3 to 1	.....do	5.8	19	....do ...	Aug. 20
52	Section 13.....	8	3 to 1	3 to 1	.....do	3.9	18	Sept. 27	June 18
53	Section 15.....	8	3 to 1	3 to 1	.....do	4	14.6	....do ...	June 20
	Ashley:							1898.	1899.
54	Section 2.....	8	3 to 1	3 to 1	New.....	.....	11.1	Oct. 8	Apr. 8
55	Section 3.....	8	3 to 1	3 to 1	.....do	.....	10	....do ...	Mar. 17
56	Section 12.....	8	3 to 1	3 to 1	.....do	.....	11	....do ...	Apr. 9
57	Section 13.....	8	3 to 1	3 to 1	.....do	.....	10.8	....do ... 1896.	Apr. 18 1898.
58	Ashley to Fairview, section 6.	8	3 to 1	3 to 1	Enlargement .	2.1	13.3	Oct. 26	Nov. 6

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Fourth district levees, 1898–99—Continued.

LOWER TENSAS LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
	Panola:	*Cubic yds.*	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 1.....	14,298.96	10.45	$1,494.24	3,000	3,200	3,100	Stationary.
2	Section 2.....	12,673.52	10.45	1,346.63	4,800	5,000	4,900	Do.
3	Section 5.....	14,896.54	11.00	1,638.62	5,000	5,200	5,100	Making.
4	Section 6.....	13,231.46	11.00	1,455.46	4,500	4,700	4,600	Do.
	Duckpond:							
5	Section 3.....	19,455.77	14.98	2,914.48	600	1,100	850	Caving.
6	Section 4.....	14,091.26	14.88	2,096.78	300	600	450	Do.
7	Kempe.....	99,155.99	16.45	16,311.17	450	1,200	825	Do.
	Stockbridge:							
8	Section 5.....	15,551.08	13.00	2,021.64	1,320	1,800	1,560	Do.
9	Section 6.....	10,293.74	9.23	950.11	1,320	1,800	1,460	Do.
10	Section 7.....	9,793.94	9.23	903.98	1,600	2,200	1,900	Do.
11	Section 8.....	11,003.58	9.23	1,015.63	2,200	2,640	2,420	Stationary.
12	Section 9.....	10,297.31	9.23	950.44	2,640	2,640	2,640	Do.
	Waterproof:							
13	Section 1.....	18,289.53	11.97	2,189.25	3,300	3,300	3,300	Do.
14	Section 2.....	19,253.84	11.97	2,304.68	3,300	3,800	3,550	Do.
15	Section 3.....	17,197.17	11.97	2,058.50	3,800	5,690	4,745	Do.
16	Section 4.....	18,055.70	11.97	2,161.27	5,690	6,190	5,940	Do.
	L'Argent:							
17	Section 1.....	14,504.75	14.40	2,088.68	3,300	3,300	3,300	Caving.
18	Section 2.....	17,968.17	14.40	2,587.42	3,210	3,210	3,210	Do.
19	Section 3.....	15,486.31	14.40	2,230.03	3,210	3,210	3,210	Do.
20	Section 4.....	15,650.66	14.40	2,253.70	3,215	3,215	3,215	Do.
21	Section 5.....	12,870.75	14.40	1,853.39	3,220	3,220	3,220	Do.
22	Section 6.....	16,227.48	14.40	2,336.76	3,130	3,130	3,130	Do.
23	Section 7.....	17,258.52	14.40	2,485.23	3,100	3,100	3,100	Do.
24	Section 8.....	12,387.63	14.40	1,783.82	3,075	3,075	3,075	Do.
25	Section 9.....	15,337.61	14.40	2,208.62	3,050	3,050	3,050	Do.
26	Section 10.....	16,528.62	14.40	2,380.12	3,025	3,025	3,025	Do.
27	Section 11.....	16,430.68	14.40	2,366.02	3,000	3,000	3,000	Do.
28	Section 12.....	16,244.98	14.40	2,339.28	2,970	2,970	2,970	Do.
29	Section 13.....	17,224.12	14.40	2,480.27	2,950	2,950	2,950	Do.
30	Section 14.....	17,540.54	14.40	2,525.84	2,900	2,900	2,900	Do.
31	Section 15.....	17,126.36	14.40	2,466.20	2,880	2,880	2,880	Do.
32	Section 16.....	16,305.74	14.40	2,348.03	2,850	2,850	2,850	Do.
33	Section 17.....	13,802.30	14.40	1,987.53	2,825	2,825	2,825	Do.
34	Section 18.....	13,404.98	14.40	1,930.32	2,805	2,805	2,805	Do.
35	Section 19.....	13,189.18	14.40	1,899.24	2,775	2,775	2,775	Do.
36	Section 20.....	13,649.67	14.40	1,965.33	2,750	2,750	2,750	Do.
37	Section 21.....	16,017.65	14.40	2,306.54	2,720	2,720	2,720	Do.
38	Section 22.....	15,016.33	14.40	2,162.35	2,700	2,700	2,700	Do.
39	Section 23.....	15,606.35	14.40	2,247.31	2,675	2,675	2,675	Do.
40	Section 24.....	18,270.24	14.40	2,630.91	2,640	2,640	2,640	Do.
	Delhi:							
41	Section 5.....	14,997.89	13.00	1,949.06	1,620	1,664	1,642	Stationary.
42	Section 6.....	12,816.78	13.00	1,666.18	1,664	1,836	1,750	Do.
43	Section 9.....	14,732.52	13.00	1,915.23	1,836	1,844	1,840	Do.
44	Section 10.....	14,110.18	13.00	1,834.32	1,844	1,956	1,900	Do.
45	Section 11.....	16,109.03	13.00	2,094.17	1,956	2,004	1,980	Do.
46	Section 13.....	15,330.22	13.00	1,992.93	1,796	2,004	1,900	Do.
47	Section 14.....	14,425.65	13.00	1,875.33	1,796	1,904	1,850	Do.
48	Section 15.....	11,384.32	13.00	1,479.97	1,800	1,800	1,800	Do.
49	Rifle Point, section 1.	31,931.78	8.70	2,778.07	7,260	7,260	7,260	Making.
	Esperanza:							
50	Section 6.....	15,080.85	19.90	3,001.09	2,900	3,100	3,000	Stationary.
51	Section 10.....	15,911.05	19.90	3,166.30	2,600	2,800	2,700	Do.
52	Section 13.....	15,520.77	19.00	2,948.95	2,400	2,500	2,450	Caving.
53	Section 15.....	15,243.94	19.00	2,896.35	2,600	2,600	2,600	Do.
	Ashley:							
54	Section 2.....	18,455.95	11.36	2,096.59	2,850	3,150	3,000	Do.
55	Section 3.....	18,999.24	11.36	2,056.07	3,150	3,850	3,500	Do.
56	Section 12.....	18,281.10	11.36	2,076.73	2,700	4,100	3,400	Do.
57	Section 13.....	16,898.17	11.36	1,919.63	2,700	2,300	2,500	Do.
58	Ashley to Fairview, section 6.	24,669.54	11.00	2,713.65	900	1,100	1,000	Do.

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Fourth district levees, 1898–99—Continued.

LOWER TENSAS LEVEE DISTRICT—(UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Palmyra Island ...	622	R.	Theo. A. Helgason.....	10,310	10,000	—0.5
	Panola:						
2	Section 3.....	646	R.	J. G. Boney	1,700	1,400	3
3	Section 4.....	647	R.	.....do	1,700	1,400	3
4	Section 7.....	647	R.	.....do	1,762	1,400	3
	Duckpond:						
5	Section 1.....	650	R.	C. E. Ponder	4,868	4,500	3
6	Section 2.....	650	R.	.....do	2,300	2,000	3
7	Kempe (extension)	657	R.	United States	1,982	1,980	1
	Stockridge:						
8	Section 1.....	659	R.	Clark & Reagan	1,629	1,320	3
9	Section 2.....	659	R.	.....do	1,600	1,300	3
10	Section 3.....	659	R.	.....do	1,200	1,200	3
11	Section 4.....	659	R.	.....do	1,300	1,300	3
	Aquasco:						
12	Section 1.....	679	R.	James R. Marlow.....	1,597	1,500	5.4
13	Section 2.....	679	R.	.....do	1,700	1,700	5.4
14	Section 3.....	679	R.	.....do	2,230	2,200	5.4
	Esperanza:						
15	Section 1.....	711	R.	Batt O'Brien.....	900	900	5.7
16	Section 2.....	711	R.	.....do	1,000	1,200	5.7
17	Section 3.....	711	R.	.....do	900	1,200	5.7
18	Section 4.....	711	R.	.....do	800	1,000	5.7
	Ashley:						
19	Section 1.....	724	R.	Jno. Scott & Sons.....	995	900	3
20	Section 4.....	724	R.	.....do	1,400	1,400	3
21	Section 5.....	724	R.	.....do	1,200	1,200	3
22	Section 6.....	724	R.	.....do	1,100	1,000	3
23	Section 7.....	724	R.	.....do	700	700	3
24	Section 8.....	724	R.	.....do	600	600	3
25	Section 9.....	724	R.	.....do	600	600	3
26	Section 10.....	724	R.	.....do	900	900	3
27	Section 11.....	724	R.	.....do	1,000	400	3
28	Ashley to Fairview, section 5.	725	R.	D. P. Lyles	2,800	2,500	3

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Cubic yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1899.	*Cu. yds.*
	Palmyra Island ..	6	2½ to 1	2½ to 1	Enlargement .	0.7	10.4	Feb. 11	22,383.00
	Panola:							1898.	
2	Section 3.....	8	3 to 1	3 to 1	.....do	1.2	14.9	July 23	13,135.31
3	Section 4.....	8	3 to 1	3 to 1	.....do	1.4	12.9	....do ...	13,793.26
4	Section 7.....	8	3 to 1	3 to 1	.....do	1.9	13.6	....do ...	13,563.85
	Duckpond:								
5	Section 1.....	8	3 to 1	3 to 1	.....do	1.4	15.3	....do ...	16,993.50
6	Section 2.....	8	3 to 1	3 to 1	.....do	1.1	13.2	....do ...	16,994.71
7	Kempe (extension).	8	3 to 1	3 to 1	New	.....	19.9	None.	85,000.00
	Stockridge:							1898.	
8	Section 1.....	8	3 to 1	3 to 1	Enlargement .	2.0	15.3	July 23	15,139.47
9	Section 2.....	8	3 to 1	3 to 1	.....do	1.9	15.4	....do ...	14,590.84
10	Section 3.....	8	3 to 1	3 to 1	.....do	2.3	16.3	....do ...	15,635.40
11	Section 4.....	8	3 to 1	3 to 1	.....do	1.5	16.4	....do ...	14,619.66
	Aquasco:							1899.	
12	Section 1.....	8	3 to 1	3 to 1	.....do	2.0	14.6	Apr. 18	13,139.16
13	Section 2.....	8	3 to 1	3 to 1	.....do	2.3	14.7	....do ...	13,519.69
14	Section 3.....	8	3 to 1	3 to 1	.....do	1.9	13.5	....do ...	13,831.14
	Esperanza:							1898.	
15	Section 1.....	8	3 to 1	3 to 1	.....do	5.0	18.0	Oct. 8	14,599.98
16	Section 2.....	8	3 to 1	3 to 1	.....do	4.9	17.7	....do ...	15,755.02
17	Section 3.....	8	3 to 1	3 to 1	.....do	5.1	18.0	....do ...	14,810.06
18	Section 4.....	8	3 to 1	3 to 1	.....do	5.4	18.3	....do ...	14,523.12
	Ashley:								
19	Section 1.....	8	3 to 1	3 to 1	New	.....	11.6	....do ...	17,706.11
20	Section 4.....	8	3 to 1	3 to 1	.....do	.....	9.4	....do ...	19,363.43
21	Section 5.....	8	3 to 1	3 to 1	.....do	.....	10.3	....do ...	19,078.33

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Fourth district levees, 1898–99—Continued.

LOWER TENSAS LEVEE DISTRICT (UNCOMPLETED LEVEES)—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Cubic yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Ashley—Cont'd.	*Feet.*				*Feet.*	*Feet.*	1898.	*Cu. yds.*
22	Section 6.....	8	3 to 1	3 to 1	New.....	.....	10.8	Oct. 8	19,100.89
23	Section 7.....	8	3 to 1	3 to 1	.....do	.....	11.1	.....do ...	15,331.94
24	Section 8.....	8	3 to 1	3 to 1	.....do	.....	12.7	.....do ...	15,584.71
25	Section 9.....	8	3 to 1	3 to 1	.....do	.....	14.0	.....do ...	15,524.71
26	Section 10....	8	3 to 1	3 to 1	.....do	.....	13.1	.....do ...	17,300.00
27	Section 11....	8	3 to 1	3 to 1	.....do	.....	11.8	.....do ...	17,931.22
								1896.	
28	Ashley to Fairview, section 5.	8	3 to 1	3 to 1	Enlargement .	2.3	14.0	Oct. 26	25,621.52

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
		Cents.	*Feet.*	*Feet.*	*Feet.*		
1	Palmyra Island .	10.90	2,640	3,960	3,300	Stationary..	97.50 per cent completed.
	Panola:						
2	Section 3.....	11.00	6,600	7,000	6,800	Making.....	Nothing done.
3	Section 4.....	11.00	6,000	6,200	6,100	.....do	Do.
4	Section 7.....	11.00	3,300	3,500	3,400	.....do	Do.
	Duckpond:						
5	Section 1.....	14.98	1,200	1,320	1,260	Caving	Do.
6	Section 2.....	14.98	1,100	1,200	1,150	.....do	11.3 per cent completed.
7	Kempe (extension).	None.	800	1,400	1,100	.....do	Embankment sinking.
	Stockridge:						
8	Section 1.....	13.00	3,870	5,500	4,685	.....do	100 per cent completed.
9	Section 2.....	13.00	2,270	3,870	3,070	.....do	64.1 per cent completed.
10	Section 3.....	13.00	2,270	2,270	2,270	.....do	Nothing done.
11	Section 4.....	13.00	1,300	1,800	2,270	.....do	40.6 per cent completed.
	Aquasco:						
12	Section 1.....	11.99	1,980	2,640	2,310	.....do	Nothing done.
13	Section 2.....	11.99	1,980	1,980	1,980	.....do	Do.
14	Section 3.....	11.99	1,500	1,980	1,740	.....do	Do.
	Esperanza:						
15	Section 1.....	19.90	2,600	2,600	2,600	Stationary..	Do.
16	Section 2.....	19.90	3,000	3,000	3,000	.....do	Do.
17	Section 3.....	19.90	3,200	3,400	3,300	.....do	Do.
18	Section 4.....	19.90	3,200	3,200	3,200	.....do	12.6 per cent completed.
	Ashley:						
19	Section 1.....	11.36	2,650	2,860	2,750	Caving	32.5 per cent completed.
20	Section 4.....	11.36	3,850	4,150	4,000	.....do	75 per cent completed.
21	Section 5.....	11.36	4,150	4,050	4,100	.....do	30 per cent completed.
22	Section 6.....	11.36	4,600	4,800	4,700	.....do	100 per cent completed.
23	Section 7.....	11.36	4,800	4,800	4,800	.....do	98 per cent completed.
24	Section 8.....	11.36	4,700	4,700	4,700	.....do	Nothing done.
25	Section 9.....	11.36	4,700	4,700	4,700	.....do	5 per cent completed.
26	Section 10....	11.36	4,700	4,700	4,700	.....do	30 per cent completed.
27	Section 11....	11.36	4,100	4,700	4,400	.....do	80 per cent completed.
28	Ashley to Fairview, section 5.	14.50	800	1,000	900	.....do	46 per cent completed.

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Fourth district levees, 1898–99—Continued.

ATCHAFALAYA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Raccourci to Longwood:				*Feet.*	*Feet.*	*Feet.*
1	Section 6	785	R.	E. P. White	1,920	1,500	2.5
2	Section 7	785	R.	do	2,000	1,800	2.5
3	Section 8	785	R.	do	2,000	1,900	2.5
	Fleta:						
4	Section 2	786	R.	do	1,000	900	5.7
5	Section 3	786	R.	do	1,020	900	5.7
6	New Texas	786	R.	do	1,400	1,300	2.8
	Poche to Morganza:						
7	Section 4 (extension).	787	R.	do	645	600	2.8
8	Section 4	787	R.	do	3,400	2,400	2.8
	Morrison:						
9	Section 7	797	R.	George Y. Andrews	900	800	5.7
10	Section 9	797	R.	Hearin & O'Connor	1,100	1,050	5.7
11	Section 10	797	R.	do	800	770	5.7
12	Section 11	797	R.	do	572	550	3.7
13	Section 12	797	R.	do	1,435	1,400	5.7
14	Section 13	797	R.	do	1,019	1,000	5.7
15	Section 14	797	R.	do	900	900	5.6
16	Section 15	797	R.	do	845	840	5.6
17	Point Coupee: Section 2.	798	R.	George Y. Andrews	1,000	1,000	5.6
18	St. Claude (part)	805	R.	F. M. McLaughlin	2,210	2,200	5.4
	Nina:						
19	Section 1	806	R.	do	1,100	1,050	5.4
20	Section 2	806	R.	do	1,000	950	5.4
21	Section 3	806	R.	do	900	850	5.4
22	Section 4	806	R.	do	1,100	1,050	5.4
23	Section 5	806	R.	do	1,100	1,050	5.4
24	Section 7	806	R.	do	1,100	900	5.4
	Highland:						
25	Section 1	815	R.	Israel R. Bobbitt	1,214	1,150	4.4
26	Section 2	815	R.	do	1,100	1,100	4.4
27	Section 3	815	R.	do	1,200	1,100	4.4
28	Section 4	815	R.	do	829	800	4.4
29	Barrosa: Sections 11–14.	824	R.	Dilworth-Scudder Dredging Co.	2,872	230	4.2
	Belle Vale:						
30	Section 1	826	R.	Israel R. Bobbitt	1,713	1,700	4.0
31	Section 2	826	R.	do	1,675	1,670	4.0
	Viola:						
32	Section 1	828	R.	do	1,569	1,400	4.4
33	Section 2	828	R.	do	1,500	1,600	4.4
34	Section 3	828	R.	do	1,500	1,500	4.4
35	Section 4	828	R.	do	1,500	3,000	4.4
36	Section 5	828	R.	do	1,457	2,500	4.4
	Beaulieu to Antonio:						
37	Section 3	836	R.	M. L. Linnan	1,500	1,500	3.0
38	Section 4	836	R.	do	1,600	1,700	3.0
39	Section 6	836	R.	do	1,800	1,900	3.0
40	Missouri: Section 1	840	R.	Israel R. Bobbitt	2,000	2,000	3.0
	Robertson:						
41	Section 1	854	R.	W. F. Barbour & Son	604	400	4.3
42	Section 2	854	R.	do	582	400	4.3
43	Sections 427–430	870	R.	F. M. McLaughlin	3,125	3,000	2.0

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Fourth district levees, 1898–99—Continued.

ATCHAFALAYA LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Raccourci to Longwood:	*Feet.*				*Feet.*	*Feet.*	1896.	1898.
1	Section 6	8	2½ to 1	3 to 1	Enlargement	1.6	15.6	May 4	Nov. 9
2	Section 7	8	2½ to 1	3 to 1	do	1.3	13.8	do	Do.
3	Section 8	8	2½ to 1	3 to 1	do	1.3	8.5	do	Oct. 15
	Fleta:							1897.	
4	Section 2	8	3 to 1	3 to 1	do	3.2	21.2	Sept. 11	Nov. 12
5	Section 3	8	3 to 1	3 to 1	do	3.4	22.0	do	Oct. 18
								1896.	
6	New Texas	8	3 to 1	3 to 1	do	0.8	17.1	May 4	Aug. 17
	Poche to Morganza:								
7	Section 4 (extension).	8	2½ to 1	3 to 1	do	0.8	16.9	do	Oct. 15
8	Section 4	8	2½ to 1	3 to 1	do	3.7	16.6	do	Do.
	Morrison:							1897.	
9	Section 7	8	2½ to 1	3 to 1	do	3.8	22.9	Sept. 11	Nov. 1
								1898.	
10	Section 9	8	3 to 1	3 to 1	do	2.9	17.2	Jan. 6	Sept. 4
11	Section 10	8	3 to 1	3 to 1	do	3.4	18.9	do	Oct. 12
12	Section 11	8	3 to 1	3 to 1	do	1.2	16.7	do	Dec. 6
13	Section 12	8	3 to 1	3 to 1	do	3.5	17.9	do	Oct. 12
14	Section 13	8	3 to 1	3 to 1	do	3.2	17.6	do	Sept. 4
15	Section 14	8	3 to 1	3 to 1	do	3.2	17.3	do	Oct. 16
16	Section 15	8	3 to 1	3 to 1	do	2.9	17.6	do	Oct. 26
								1897.	
17	Point Coupee: Section 2.	8	3 to 1	3 to 1	do	3.8	15.2	Sept. 11	Oct. 11
								1898.	
18	St. Claude (part)	8	3 to 1	3 to 1	do	2.9	16.0	Jan. 5	Aug. 13
	Nina:								
19	Section 1	8	3 to 1	3 to 1	do	3.4	19.0	do	Dec. 22
20	Section 2	8	3 to 1	3 to 1	do	3.6	16.4	do	Dec. 31
								1899.	
21	Section 3	8	3 to 1	3 to 1	do	3.5	18.6	do	Feb. 28
								1898.	
22	Section 4	8	3 to 1	3 to 1	do	3.5	17.1	do	Sept. 22
23	Section 5	8	3 to 1	3 to 1	do	3.2	17.5	do	Do.
								1899.	
24	Section 7	8	3 to 1	3 to 1	do	3.1	15.7	do	Mar. 23
	Highland:							1897.	1898.
25	Section 1	8	3 to 1	3 to 1	do	2.9	19.2	Sept. 11	Nov. 2
26	Section 2	8	3 to 1	3 to 1	do	2.8	20.7	do	Do.
27	Section 3	8	3 to 1	3 to 1	do	2.9	19.4	do	Do.
28	Section 4	8	3 to 1	3 to 1	do	2.9	18.5	do	Do.
								1898.	
29	Barroza: Sections 11–14.	8	3 to 1	3 to 1	do	2.8	20.1	June 1	Part.
	Belle Vale:								1898.
30	Section 1	8	3 to 1	3 to 1	do	2.6	14.9	Jan. 5	Oct. 6
31	Section 2	8	3 to 1	3 to 1	do	2.7	15.4	do	Dec. 16
	Viola:								
32	Section 1	8	3 to 1	3 to 1	do	2.0	15.0	do	June 14
33	Section 2	8	3 to 1	3 to 1	do	1.9	15.1	do	July 12
34	Section 3	8	3 to 1	3 to 1	do	2.6	16.1	do	Aug. 16
35	Section 4	8	3 to 1	3 to 1	do	2.6	15.1	do	Do.
36	Section 5	8	3 to 1	3 to 1	do	2.7	15.1	do	Aug. 1
	Beaulieu to Antonio:								1899.
37	Section 3	8	3 to 1	3 to 1	do	1.9	15.2	Oct. 1	Mar. 24
38	Section 4	8	3 to 1	3 to 1	do	2.0	14.3	do	Feb. 17
39	Section 6	8	3 to 1	3 to 1	New		14.3	do	Mar. 24
40	Missouri: Sec. 1	8	3 to 1	3 to 1	Enlargement	2.5	14.4	do	Mar. 20
	Robertson:								
41	Section 1	8	3 to 1	3 to 1	New		16.2	Dec. 28	Apr. 12
42	Section 2	8	3 to 1	3 to 1	do		14.9	do	Do.
								1896.	1898.
43	Sections 427–430	8	2½ to 1	3 to 1	Enlargement	1.6	11.6	Nov. 12	Nov. 26

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Fourth district levees, 1898–99—Continued.

ATCHAFALAYA LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
	Raccourci to Longwood:	*Cu. yds.*	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 6	9,738.63	9	$876.48	14,000	14,800	14,400	Stationary.
2	Section 7	8,026.53	9	722.39	15,000	18,000	16,500	Do.
3	Section 8	8,368.46	18	753.16	18,000	22,000	20,000	Do.
	Fleta:							
4	Section 2	19,807.40	18	3,565.33	740	780	760	Caving.
5	Section 3	19,352.02	18	3,483.36	740	930	840	Do.
6	New Texas	11,136.49	10	1,113.65	840	920	880	Do.
	Poche to Morganza:							
7	Section 4 (extension).	4,129.07	14	578.07	840	920	880	Do.
8	Section 4	31,078.51	14	4,350.99	1,100	1,650	1,500	Do.
	Morrison:							
9	Section 7	18,652.30	13.75	2,564.69	900	1,300	1,200	Making.
10	Section 9	16,000.18	12.50	2,000.02	220	740	480	Do.
11	Section 10	14,650.36	12.50	1,831.30	120	220	148	Do.
12	Section 11	6,425.12	12.50	803.14	148	205	160	Do.
13	Section 12	23,866.99	12.50	2,983.37	160	240	200	Do.
14	Section 13	19,888.42	12.50	2,486.05	200	280	240	Do.
15	Section 14	14,978.60	12.50	1,872.38	180	210	190	Do.
16	Section 15	15,275.37	12.50	1,909.42	160	200	190	Do.
17	Point Coupee, Section 2.	14,263.03	13.75	1,961.17	120	160	150	Washing.
18	St. Claude (part)	14,278.72	16.25	2,320.30	200	940	700	Caving slowly.
	Nina:							
19	Section 1	18,636.97	16.25	3,028.51	1,980	2,200	2,100	Caving.
20	Section 2	16,304.64	16.25	2,649.50	1,400	1,980	1,800	Do.
21	Section 3	15,935.32	16.25	2,589.49	1,100	1,400	1,300	Do.
22	Section 4	17,655.23	16.25	2,868.97	700	1,100	900	Do.
23	Section 5	16,528.58	16.25	2,685.89	620	700	680	Do.
24	Section 7	16,553.36	16.26	2,689.92	1,000	1,360	1,200	Do.
	Highland:							
25	Section 1	19,811.18	15⅜	3,045.97	1,300	1,380	1,340	Do.
26	Section 2	20,644.97	15⅜	3,174.16	1,260	1,380	1,380	Do.
27	Section 3	19,349.34	15⅜	2,974.96	1,180	1,260	1,220	Do.
28	Section 4	13,538.88	15⅜	2,081.60	700	1,180	900	Do.
29	Barrosa, Sections 11–14.	37,600	14	5,263.00	900	1,100	1,100	Do.
	Belle Vale:							
30	Section 1	15,381.92	12.50	1,922.74	320	450	380	Do.
31	Section 2	14,674.71	12.50	1,834.34	320	400	360	Do.
	Viola:							
32	Section 1	14,271.68	12.50	1,783.96	260	340	300	Do.
33	Section 2	15,090.60	12.50	1,886.32	280	540	430	Do.
34	Section 3	15,686.19	12.50	1,960.77	540	700	600	Do.
35	Section 4	15,752.14	12.50	1,969.02	600	300	450	Washing.
36	Section 5	15,880.68	12.50	1,985.09	300	300	300	Do.
	Beaulieu to Antonio:							
37	Section 3	15,895.04	10.97	1,743.69	180	540	280	Making.
38	Section 4	15,259.51	10.97	1,673.97	160	200	180	Do.
39	Section 6	16,746.79	10.97	1,837.13	140	240	200	Do.
40	Missouri, Section 1.	15,197.14	14.50	2,203.59	240	290	270	Caving.
	Robertson:							
41	Section 1	19,601.25	22	4,331.90	600	700	650	Do.
42	Section 2	17,042.59	22	3,749.37	600	700	650	Do.
43	Sections 427–430	12,155.84	11	1,337.14	390	450	430	Washing.

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Fourth district levees 1898–99—Continued.

ATCHAFALAYA LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Nina:				*Feet.*	*Feet.*	*Feet.*
1	Section 6	806	R.	F. M. McLaughlin	1,000	500	5.4
2	Section 8	806	R.	do	1,100	1,000	5.4
	Barroza:						
3	Section 11	824	R.	Dilworth-Scudder Dredging Co.	237	230	4.2
4	Section 12	824	R.	do	1,000	1,000	4.2
5	Section 13	824	R.	do	900	900	4.2
6	Section 14	824	R.	do	735	730	4.2
	Beaulieu to Antonio:						
7	Section 1	836	R.	M. L. Linnan	1,600	1,600	3
8	Section 2	836	R.	do	1,400	1,300	3
9	Section 5	836	R.	do	1,400	1,500	3
	Missouri:						
10	Section 2	840	R.	Israel R. Bobbitt	1,700	1,400	3
11	Section 3	840	R.	do	1,600	1,600	3
12	Section 4	840	R.	do	1,736	1,500	3
	Australia:						
13	Section 1	846	R.	M. L. Linnan	1,870	2,900	3
14	Section 2	846	R.	do	1,962	2,900	3

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Nina:	*Feet.*				*Feet.*	*Feet.*	1898.	*Cubic yds.*
1	Section 6	8	3 to 1	3 to 1	Enlargement	3	19.7	Jan. 5	16,810.89
2	Section 8	8	3 to 1	3 to 1	do	3.2	18.4	Jan. 5	19,008.55
	Barroza:								
3	Section 11	8	3 to 1	3 to 1	do	2.3	20.1	June 1	3,664.13
4	Section 12	8	3 to 1	3 to 1	do	3	20.4	June 1	15,871.74
5	Section 13	8	3 to 1	3 to 1	do	3.2	21.2	June 1	15,767.66
6	Section 14	8	3 to 1	3 to 1	do	2.6	21.8	June 1	10,936.71
	Beaulieu to Antonio:								
7	Section 1	8	3 to 1	3 to 1	do	2.3	15.2	Oct. 1	15,767.52
8	Section 2	8	3 to 1	3 to 1	do	2.2	15.2	Oct. 1	15,457.84
9	Section 5	8	3 to 1	3 to 1	New and enlargement.	1.9	14.2	Oct. 1	15,888.62
	Missouri:								
10	Section 2	8	3 to 1	3 to 1	Enlargement	2.2	15.2	Oct. 1	16,332.99
11	Section 3	8	3 to 1	3 to 1	do	2.4	15.6	Oct. 1	15,357.85
12	Section 4	8	3 to 1	3 to 1	do	3.1	16.1	Oct. 1	15,868.88
	Australia:								
13	Section 1	8	3 to 1	3 to 1	do	2.2	12.7	Oct. 1	12,927.41
14	Section 2	8	3 to 1	3 to 1	do	2.4	12.4	Oct. 1	12,793.17

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
	Nina:	*Cents.*	*Feet.*	*Feet.*	*Feet.*		
1	Section 6	16.25	680	1,000	750	Caving	58 per cent completed.
2	Section 8	16.25	1,320	1,600	1,500	do	Nothing done.
	Barroza:						
3	Section 11	14	1,050	1,100	1,100	do	99 per cent completed.
4	Section 12	14	760	1,100	1,000	do	Do.
5	Section 13	14	760	1,100	1,000	do	Do.
6	Section 14	14	840	1,100	1,000	do	Do.
	Beaulieu to Antonio:						
7	Section 1	10.97	480	600	540	Making	Nothing done.
8	Section 2	10.97	500	540	530	do	30 per cent completed.
9	Section 5	10.97	120	180	160	do	67 per cent completed.
	Missouri:						
10	Section 2	14.50	250	450	400	Caving	48 per cent completed.
11	Section 3	14.50	450	635	600	do	Nothing done.
12	Section 4	14.50	200	640	600	do	31 per cent completed.
	Australia:						
13	Section 1	10.97	160	560	380	Washing	50 per cent completed.
14	Section 2	10.97	220	560	400	do	96 per cent completed.

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Fourth district levees, 1898–99—Continued.

LAFOURCHE LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Waguespack:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	906	R.	James H. Cary	2,890	2,800	3
2	Section 2	906	R.	do	2,200	2,100	2.8
3	Section 4	906	R.	do	2,600	2,600	2.6
	Stevenson:						
4	Section 1	919	R.	do	2,685	2,600	2.6
5	Section 2	919	R.	do	2,900	2,600	2.6
6	Section 3	919	R.	do	2,261	2,200	2.7
	Pelican to Flagtown:						
7	Section 1	936	R.	Hayes Bros	2,752	2,700	3
8	Section 2	936	R.	do	2,500	2,500	3
9	Section 3	936	R.	do	2,500	3,000	3
10	Section 4	936	R.	do	2,100	2,500	2.9
11	Louisa, section 1	943	R.	Donovan & Daly	2,452	2,400	2.7

No.	Name of levee.	Section.			New or Enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Waguespack:	*Feet.*				*Feet.*	*Feet.*	1897.	1898.
1	Section 1	8	3 to 1	3 to 1	Enlargement	1.1	10.3	Dec. 27	Aug. 31
2	Section 2	8	3 to 1	3 to 1	do	1.3	12.3	do	Sept. 2
3	Section 4	8	3 to 1	3 to 1	do	1.2	10.6	do	Sept. 24
	Stevenson:								
4	Section 1	8	3 to 1	3 to 1	do	1.2	12	do	Dec. 29
5	Section 2	8	3 to 1	3 to 1	do	1.4	13.3	do	Mar. 3
6	Section 3	8	3 to 1	3 to 1	do	1.2	12.3	do	Dec. 26
	Pelican to Flagtown:							1898.	1899.
7	Section 1	8	3 to 1	3 to 1	do	1.6	12	Oct. 1	Mar. 13
8	Section 2	8	3 to 1	3 to 1	do	1.5	10	do	1898. Dec. 12
9	Section 3	8	3 to 1	3 to 1	do	1.4	10	do	1899. Jan. 5
10	Section 4	8	3 to 1	3 to 1	do	1.7	11.2	do	Mar. 4
11	Louisa, section 1	8	3 to 1	3 to 1	do	1.5	10	do	Jan. 4

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
	Waguespack:	*Cu. yds.*	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 1	15,810.36	10	$1,581.04	103	200	150	Washing.
2	Section 2	15,708.74	10	1,570.87	126	160	150	Do.
3	Section 4	15,748.47	10	1,574.85	115	150	140	Do.
	Stevenson:							
4	Section 1	15,321.56	12.07	1,861.38	120	214	200	Caving.
5	Section 2	17,340.22	12.56	2,177.94	175	410	300	Do.
6	Section 3	14,933.60	12.56	1,875.66	225	360	275	Do.
	Pelican to Flagtown:							
7	Section 1	15,594.29	12.75	1,988 26	110	200	140	Washing.
8	Section 2	15,756.51	12.75	2,008.96	75	300	150	Making.
9	Section 3	16,382.63	12.75	2,084.96	300	600	500	Do.
10	Section 4	16,786.09	12.75	2,140.23	480	643	500	Do.
11	Louisa, section 1	18,365.55	13.90	2,552.82	200	236	220	Caving.

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Fourth district levees, 1898–99—Continued.

LAFOURCHE LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Jamestown	898	R.	James H. Cary	2,167	2,707	2.8
	Bay Tree:						
2	Section 1	906	R.	do	2,765	2,765	2.8
3	Section 2	906	R.	do	2,000	1,800	2.7
4	Section 3	906	R.	do	1,300	1,300	2.6
5	Section 4	906	R.	do	1,400	1,400	2.6
6	Section 5	906	R.	do	1,500	1,300	2.7
7	Section 6	906	R.	do	1,078	1,600	2.8
8	Willow Grove	916	R.	do	2,920	2,900	2.5
	Alliance:						
9	Section 1	920	R.	do	2,434	2,400	3.1
10	Section 2	920	R.	do	3,050	3,000	3
	Hymelia to Kilona:						
11	Section 1	930	R.	Hayes Bros	2,800	3,000	3
12	Section 2	930	R.	do	2,300	2,200	2.9
13	Section 3	930	R.	do	2,300	2,200	2.9
14	Section 4	930	R.	do	1,800	1,800	3
15	Section 5	930	R.	do	2,364	2,300	2.8
16	Pelican to Flagtown, section 5.	936	R.	do	2,879	2,800	3
17	Lone Star	942	R.	do	2,047	1,900	2.9
18	Louisa, section 2	943	R.	Donovan & Daly	3,200	3,200	2.7
19	Coopersville	944	R.	Jas. A. Andrews & Son	2,632	2,500	2.9

No.	Name of levee.	Section.			Average height.			Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.	New or enlargement.	Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1898.	*Cu. yds.*
1	Jamestown	8	3 to 1	3 to 1	Enlargement	2	12	Dec. 27	13,166.67
	Bay Tree:								
2	Section 1	8	3 to 1	3 to 1	do	1.5	12	do	15,054.94
3	Section 2	8	3 to 1	3 to 1	do	1.4	14.6	do	14,862.04
4	Section 3	8	3 to 1	3 to 1	do	1.8	16	do	15,130.41
5	Section 4	8	3 to 1	3 to 1	do	1.3	12.6	do	15,170.96
6	Section 5	8	3 to 1	3 to 1	do	1.5	12.6	do	14,792.23
7	Section 6	8	3 to 1	3 to 1	do	1.5	10.3	do	13,497.62
8	Willow Grove	8	3 to 1	3 to 1	do	1.3	9.6	do	16,729.35
	Alliance:								
9	Section 1	8	3 to 1	3 to 1	do	1.4	13.3	do	16,428.04
10	Section 2	8	3 to 1	3 to 1	do	1.5	10.6	do	15,954.40
	Hymelia to Kilona:								
11	Section 1	8	3 to 1	3 to 1	do	1.4	11	Oct. 1	14,434.56
12	Section 2	8	3 to 1	3 to 1	do	1	9	do	14,592.57
13	Section 3	8	3 to 1	3 to 1	do	1.4	10	do	14,849.71
14	Section 4	8	3 to 1	3 to 1	do	1.4	10.3	do	14,175.38
15	Section 5	8	3 to 1	3 to 1	do	1.3	10.3	do	14,377.65
16	Pelican to Flagtown, section 5.	8	3 to 1	3 to 1	do	1.5	13	do	26,261.29
17	Lone Star	8	3 to 1	3 to 1	do	1.8	11.3	do	12,537.75
18	Louisa, section 2	8	3 to 1	3 to 1	do	1.2	11	do	18,859.97
19	Coopersville	8	3 to 1	3 to 1	do	1.5	10.6	do	11,007.69

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Fourth district levees, 1898–99—Continued.

LAFOURCHE LEVEE DISTRICT (UNCOMPLETED LEVEES)—Continued.

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
		Cents.	*Feet.*	*Feet.*	*Feet.*		
1	Jamestown	13.50	360	475	400	Caving	Nothing done.
	Bay Tree:						
2	Section 1	15.53	570	720	600	do	Do.
3	Section 2	15.53	413	700	550	do	Do.
4	Section 3	14.29	480	431	440	do	Do.
5	Section 4	14.29	483	640	550	Washing	Do.
6	Section 5	11.93	600	770	650	do	Do.
7	Section 6	11.93	157	600	300	Making	Do.
8	Willow Grove	12.07	140	280	200	Stationary	Do.
	Alliance:						
9	Section 1	11.66	250	412	300	Caving	85 per cent completed.
10	Section 2	11.66	145	316	225	Washing	Nothing done.
	Hymelia to Killona:						
11	Section 1	11.75	750	2,000	1,200	Making	Do.
12	Section 2	11.75	350	750	450	do	Do.
13	Section 3	11.75	75	350	170	Washing	Do.
14	Section 4	11.75	150	250	180	do	Do.
15	Section 5	11.75	150	254	200	do	Do.
16	Pelican to Flagtown, section 5.	12.75	350	1,100	800	Making	94 per cent completed.
17	Lone Star	18	330	190	250	Caving	Nothing done.
18	Louisa, section 2	13.90	167	260	200	do	80 per cent completed.
19	Coopersville	14.75	261	361	310	do	87 per cent completed.

BARATARIA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Deer Range	1,005	R.	Jos. Hingle, jr	1,600	1,600	2.2
2	Treadaway	1,019	R.	Michael Cullen	1,757	1,757	2.5
3	Butler	1,019	R.	do	510	510	2.7
	Ballay to Orange Farm:						
4	Section 3	1,023	R.	Victor Adema	1,700	1,600	2.5
5	Section 5	1,023	R.	W. J. Bentley & Co	2,235	2,050	2.5
6	Orange Farm	1,024	R.	Robt. McNamara	900	810	2.5
7	Nairn, section 3	1,025	R.	Dilworth-Scudder Dredging Co	3,000	3,420	2.5

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1897.	1899.
1	Deer Range	8	3 to 1	3 to 1	Enlargement	1.5	10	Dec. 29	Jan. 14
								1898.	
2	Treadaway	8	3 to 1	3 to 1	New		6.3	Nov. 19	Jan. 21
3	Butler	8	3 to 1	3 to 1	Enlargement	1.5	6.6	do	Jan. 4
	Ballay to Orange Farm:							1897.	1898.
4	Section 3	8	3 to 1	3 to 1	do	2	6	Sept. 17	Nov. 23
5	Section 5	8	3 to 1	3 to 1	New and enlargement.	2.5	6.5	do	Sept. 1
								1898.	1899.
6	Orange Farm	8	3 to 1	3 to 1	New		7.5	Oct. 27	Mar. 21
								1897.	
7	Nairn, section 3	8	3 to 1	3 to 1	Enlargement	2	5.6	Dec. 29	May 3

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Fourth district levees, 1898-99—Continued.

BARATARIA LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
		Cu. yds.	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Deer Range	5,711.80	12.20	$696.83	100	125	120	Stationary.
2	Treadaway	12,255.98	11.88	1,456.01	120	130	125	Do.
3	Butler	2,083.74	11.88	247.55	60	105	90	Washing.
	Ballay to Orange Farm:							
4	Section 3	6,624.17	11.25	746.34	50	118	75	Do.
5	Section 5	16,209.63	14.25	2,309.87	75	.....	108	Washing and caving.
6	Orange Farm	8,281.67	14.75	1,221.55	180	220	190	Caving.
7	Nairn, section 3	13,678.58	12.25	1,675.62	75	250	150	Making.

BARATARIA LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Little Rock	980	R.	Victor Adema	1,780	1,560	2.1
	Bellechasse:						
2	Section 1	982	R.	.....do	2,240	1,830	2.0
3	Section 2	982	R.	.....do	2,300	900	2.0
4	St. Ann	985	R.	Michael Cullen	3,106	3,026	2.6
	St. Rosalie:						
5	Section 1	999	R.	Wade Bros. Construction Co.	2,700	2,780	2.2
6	Section 2	999	R.	.....do	2,034	2,094	2.2
7	Magnolia	1,013	R.	Jos. Hingle, jr	4,306	4,700	2.3
8	Ballay to Orange Farm, section 4.	1,023	R.	Victor Adema	2,291	1,510	2.5
9	Nairn, section 2	1,025	R.	Dilworth-Soudder Dredging Co.	4,000	4,900	2.5
10	Pelas	1,032	R.	Robt. McNamara	1,700	1,600	2.1
11	Rodey	1,035	R.	.....do	3,312	3,100	2.3
	Rodey extension:						
12	Section 1	1,035	R.	.....do	1,650	1,650	2.3
13	Section 2	1,036	R.	.....do	3,758	3,900	2.3
14	Booth	1,039	R.	.....do	2,020	1,700	2.3

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1897.	*Cu. yds.*
1	Little Rock	8	3 to 1	3 to 1	Enlargement	0.8	8.3	Dec. 29	3,696.22
	Bellechasse:								
2	Section 1	8	3 to 1	3 to 1	.....do	0.7	9.3	....do	2,727.86
3	Section 2	8	3 to 1	3 to 1	.....do	0.2	10	....do	11,083.23
								1898.	
4	St. Ann	8	3 to 1	3 to 1	.....do	1.1	9.3	Nov. 19	9,884.04
	St. Rosalie:								
5	Section 1	8	3 to 1	3 to 1	New	.....	6.8	....do	18,761.13
6	Section 2	8	3 to 1	3 to 1	.....do	.....	8.2	....do	19,358.69
								1897.	
7	Magnolia	8	3 to 1	3 to 1	Enlargement	0.7	8.3	Dec. 29	14,695.44
8	Ballay to Orange Farm, section 4.	8	3 to 1	3 to 1	New and enlargement.	1.8	6.5	Sept. 17	14,226.35
9	Nairn, section 2	8	3 to 1	3 to 1	.....do	2.5	6	Dec. 29	16,578.58
								1898.	
10	Pelas	8	3 to 1	3 to 1	Enlargement	1.5	6.7	Oct. 27	6,817.74
11	Rodey	8	3 to 1	3 to 1	.....do	1.7	6.1	....do	13,244.88
	Rodey extension:								
12	Section 1	8	3 to 1	3 to 1	.....do	0.9	6.5	Dec. 28	5,348.51
13	Section 2	8	3 to 1	3 to 1	.....do	1.3	6.2	....do	10,919.60
14	Booth	8	3 to 1	3 to 1	.....do	1.7	6.4	Oct. 27	7,415.51

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Fourth district levees, 1898–99—Continued.

BARATARIA LEVEE DISTRICT (UNCOMPLETED LEVEES)—Continued.

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
		Cents.	*Feet.*	*Feet.*	*Feet.*		
1	Little Rock	14.75	100	215	130	Washing	54 per cent completed.
	Bellechasse:						
2	Section 1	14.75	335	427	380	do	Nothing done.
3	Section 2	14.75	278	401	290	Caving	Do.
4	St. Ann	13.25	105	235	220	Washing	Do.
	St. Rosalie:						
5	Section 1	13.50	120	140	125	Stationary	29 per cent completed.
6	Section 2	13.50	100	150	128	do	Nothing done.
7	Magnolia	12.20	139	350	220	Making	85 per cent completed.
8	Ballay to Orange Farm, section 4.	11.25	78	150	110	Washing	99 per cent completed.
9	Nairn, section 2	12.25	75	150	130	Washing and making.	Nothing done.
10	Pelas	13.875	105	121	110	Washing	55 per cent completed.
11	Rodey	15.50	200	255	240	Making	3 per cent completed.
	Rodey extension:						
12	Section 1	17.00	75	120	105	do	Nothing done.
13	Section 2	17.00	180	255	230	do	Do.
14	Booth	13.75	80	130	90	Washing	6 per cent completed.

PONTCHARTRAIN LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Section 10	837	L.	Michael Hanick	2,472	2,330	3.7
2	Section 11	837	L.	do	1,600	1,400	3.6
3	Section 12	837	L.	do	920	920	3.6
4	Section 13	838	L.	do	1,469	1,469	3.3
5	Section 14	838	L.	do	1,668	1,668	3.6
6	Section 15	838	L.	do	1,628	1,628	3.5
7	Section 16	839	L.	do	2,530	2,200	3.5
8	Section 19	839	L.	do	986	986	3.5
9	Section 20	840	L.	do	983	983	3.5
10	Section 22	840	L.	do	964	950	3.4
11	Section 24	841	L.	do	1,312	4,000	3.5
12	Section 25	841	L.	do	1,300	1,500	3.5
13	Section 34	845	L.	do	787	787	3.2
14	Section 35	845	L.	do	856	856	3.2
15	Section 41	846	L.	do	1,556	1,500	3.4
16	Section 42	846	L.	do	1,748	1,748	3.3
17	Section 43	847	L.	do	1,461	1,100	3.3
18	Section 44	847	L.	do	990	800	3.3
19	Section 45	847	L.	do	1,607	1,300	3.2
20	Section 46	848	L.	do	1,343	1,300	3.2
21	Section 47	848	L.	do	1,280	900	3.2
22	Section 72	854	L.	Clark & Reagan	1,396	1,396	3.2
23	Section 74	854	L.	do	1,072	2,000	3.3
24	Section 75	854	L.	H. J. Loonan	1,134	2,000	3.5
25	Section 76	854	L.	do	766	2,500	3.4
26	Section 77	854	L.	Clark & Reagan	1,791	1,900	3.2
27	Section 98	860	L.	Michael Hanick	2,445	2,275	3.1
28	Section 99	861	L.	do	994	994	3.1
29	Section 100	861	L.	do	800	800	3.1
30	Section 102	862	L.	do	1,166	1,166	3.1
31	Section 103	862	L.	do	426	426	3.1

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Fourth district levees, 1898-99—Continued.

PONTCHARTRAIN LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1899.	1899.
1	Section 10	8	3 to 1	3 to 1	Enlargement	3.5	22	Mch. 16	Apr. 6
2	Section 11	8	3 to 1	3 to 1	do	3.2	16	do	Do.
								1898.	
3	Section 12	8	3 to 1	3 to 1	do	2.6	14	Jan. 5	Mar. 21
4	Section 13	8	3 to 1	3 to 1	do	2.6	14	do	Mar. 23
5	Section 14	8	3 to 1	3 to 1	do	3	14.3	do	Jan. 31
								1898.	
6	Section 15	8	3 to 1	3 to 1	do	3.2	14.3	do	Sept. 3
7	Section 16	8	3 to 1	3 to 1	do	1.5	15.3	do	Nov. 2
8	Section 19	8	3 to 1	3 to 1	do	1.6	16.6	do	July 13
9	Section 20	8	3 to 1	3 to 1	do	1.5	16.6	do	Aug. 4
10	Section 22	8	3 to 1	3 to 1	do	3.1	13.3	do	July 25
11	Section 24	8	3 to 1	3 to 1	do	4	16.6	do	Aug. 6
12	Section 25	8	3 to 1	3 to 1	do	4	16.6	do	Sept. 20
13	Section 34	8	3 to 1	3 to 1	do	3.5	15	do	Do.
14	Section 35	8	3 to 1	3 to 1	do	3.5	15	do	Do.
15	Section 41	8	3 to 1	3 to 1	do	2.5	14	do	Oct. 28
16	Section 42	8	3 to 1	3 to 1	do	2.5	14	do	Dec. 6
17	Section 43	8	3 to 1	3 to 1	do	2.9	15	do	Dec. 28
								1899.	
18	Section 44	8	3 to 1	3 to 1	do	2.6	14.6	do	Jan. —
19	Section 45	8	3 to 1	3 to 1	do	3.2	14	do	Jan. 31
20	Section 46	8	3 to 1	3 to 1	do	2.5	13.6	do	Mar. 8
21	Section 47	8	3 to 1	3 to 1	do	3	13.6	do	Feb. 17
								1899.	
22	Section 72	8	3 to 1	3 to 1	do	2.8	14	Feb. 27	Mar. 29
23	Section 74	8	3 to 1	3 to 1	do	3.1	14.3	do	Apr. 12
24	Section 75	8	3 to 1	3 to 1	do	2.6	14	Mar. 2	Do.
25	Section 76	8	3 to 1	3 to 1	do	2.8	14	do	Mar. 29
26	Section 77	8	3 to 1	3 to 1	do	3	14.6	Feb. 27	Apr. 29
								1898.	
27	Section 98	8	3 to 1	3 to 1	do	2.6	15.3	Jan. 5	Feb. 10
								1898.	
28	Section 99	8	3 to 1	3 to 1	do	2.6	15.3	do	Oct. 27
29	Section 100	8	3 to 1	3 to 1	do	2.6	15.3	do	Dec. 6
								1899.	
30	Section 102	8	3 to 1	3 to 1	do	2.6	14.6	do	Mar. 28
31	Section 103	8	3 to 1	3 to 1	do	2.6	14.6	do	Mar. 3

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
		Cubic yds.	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 10	4,375.99	29	$1,269.04	257	500	350	Caving.
2	Section 11	2,585.42	29	749.77	436	575	500	Do.
3	Section 12	7,687.05	18	1,383.67	685	685	685	Washing.
4	Section 13	12,901.59	14.49	1,869.47	530	700	600	Do.
5	Section 14	14,377.08	14.49	2,083.23	385	475	400	Do.
6	Section 15	14,505.18	10.99	1,594.12	303	400	350	Do.
7	Section 16	23,798.81	10.99	2,615.49	105	210	150	Do.
8	Section 19	8,994.96	10.99	988.55	345	450	400	Do.
9	Section 20	7,965.35	10.99	875.39	312	450	380	Do.
10	Section 22	10,027.14	10.99	1,101.98	100	160	130	Making.
11	Section 24	19,243.32	10.99	2,114.90	1,200	1,200	1,200	Do.
12	Section 25	21,035.31	10.99	2,311.78	650	1,100	950	Do.
13	Section 34	7,445.47	10.99	818.26	460	500	480	Caving.
14	Section 35	7,281.37	10.99	800.82	418	460	435	Do.
15	Section 41	14,960.58	12.90	1,929.91	120	250	180	Washing.
16	Section 42	16,918.78	12.90	2,182.52	100	165	130	Do.
17	Section 43	17,178.19	12.90	2,215.99	100	200	180	Stationary.
18	Section 44	11,224.32	12.90	1,447.94	143	160	150	Do.
19	Section 45	18,106.92	12.90	2,335.79	135	150	140	Do.
20	Section 46	11,622.07	12.90	1,499.25	400	480	440	Caving.
21	Section 47	10,922.48	12.90	1,409.00	420	677	550	Do.
22	Section 72	14,379.85	13.23	1,902.45	284	472	350	Washing.
23	Section 74	10,850.82	15	1,627.62	800	700	500	Do.
24	Section 75	10,854.40	12.45	1,351.37	700	700	700	Making.
25	Section 76	7,416.00	12.45	923.34	500	900	700	Do.
26	Section 77	16,994.50	12.45	2,115.82	220	680	400	Do.
27	Section 98	25,447.30	14.49	3,687.32	234	400	350	Caving.
28	Section 99	11,068.60	14.49	1,603.84	310	350	330	Do.
29	Section 100	8,933.88	14.49	1,294.52	310	310	310	Washing.
30	Section 102	12,176.48	14.49	1,764.37	314	310	310	Do.
31	Section 103	4,493.39	14.49	651.09	330	330	330	Do.

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Fourth district levees, 1898–99—Continued.

PONTCHARTRAIN LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles above Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
1	Section 7	836	L.	Israel R. Bobbitt	2,321	2,321	3.7
2	Section 9	836	L.	do	1,946	1,946	3.9
3	Section 48	848	L.	Michael Hanick	1,519	1,100	3.2
4	Section 49	849	L.	do	1,142	800	3.2
5	Section 50	849	L.	do	1,040	1,040	3.2
6	Section 73	854	L.	Clark & Reagan	1,789	1,789	3.3
7	Section 78	854	L.	George Byrne	1,691	1,691	3.1
8	Section 97	860	L.	Michael Hanick	1,418	1,418	3.2
9	Section 101	862	L.	do	1,111	1,111	3.1

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Feet.				*Feet.*	*Feet.*	1897.	*Cu. yds.*
1	Section 7	8	3 to 1	3 to 1	Enlargement	2.2	21.2	Sept. 1	25,231.17
2	Section 9	8	3 to 1	3 to 1	do	3.6	17.3	do	23,268.25
								1898.	
3	Section 48	8	3 to 1	3 to 1	do	2.8	15	Jan. 5	13,273.01
4	Section 49	8	3 to 1	3 to 1	do	3.2	16.6	do	12,008.90
5	Section 50	8	3 to 1	3 to 1	do	3.2	16.6	do	11,378.83
								1899.	
6	Section 73	8	3 to 1	3 to 1	do	3	14.6	Feb. 27	17,305.48
7	Section 78	8	3 to 1	3 to 1	do	2.8	13.5	Mar. 2	16,874.02
								1898.	
8	Section 97	8	3 to 1	3 to 1	do	2.6	14	Jan. 5	14,450.83
9	Section 101	8	3 to 1	3 to 1	do	2.6	15.3	do	11,784.57

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
		Cents.	*Feet.*	*Feet.*	*Feet.*		
1	Section 7	17	530	700	620	Caving	16 per cent completed.
2	Section 9	17	500	762	640	do	37 per cent completed.
3	Section 48	12.90	450	650	550	do	Nothing done.
4	Section 49	12.90	308	520	350	do	Do.
5	Section 50	12.90	395	470	430	do	Do.
6	Section 73	13.23	356	472	400	do	Do.
7	Section 78	12	225	225	225	Making	32 per cent completed.
8	Section 97	14.49	300	410	400	Caving	Nothing done.
9	Section 101	14.49	300	320	310	Washing	Do.

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Fourth district levees, 1898–99—Continued.

LAKE BORGNE LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Corinne:				*Feet.*	*Feet.*	*Feet.*
1	Section 3	973.5	L.	George Jurgens	3,100	2,890	2.9
2	Section 4	974	L.	do	3,200	2,330	2.8
3	Section 5	975	L.	do	1,956	2,020	2.8
	Story to Caernarvon:						
4	Section 3	977	L.	W. F. Barbour & Son	4,400	3,990	2.9
5	Section 4	977	L.	do	3,900	3,680	2.9
6	Poydras, section 1.	978	L.	John F. Meyer	2,873	1,900	2.9
7	Caernarvon, section 1.	978.5	L.	Thos. Egan, jr	600	300	2.9

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Corinne:	*Feet.*				*Feet.*	*Feet.*	1898.	1899.
1	Section 3	8	3 to 1	3 to 1	Enlargement	2	12	Oct. 22	Mar. 10
2	Section 4	8	3 to 1	3 to 1	do	1.9	6.8	do	Do.
3	Section 5	8	3 to 1	3 to 1	New and enlargement.	2.3	8.6	do	Do.
	Story to Caernarvon:							1897.	1898.
4	Section 3	8	3 to 1	3 to 1	Enlargement	2	9	Sept. 17	Oct. 29
5	Section 4	8	3 to 1	3 to 1	do	1.8	9.7	do	Do.
								1898.	1899.
6	Poydras, section 1.	8	3 to 1	3 to 1	do	1.2	11	Oct. 22	Jan. 27
7	Caernarvon, section 1.	8	3 to 1	3 to 1	New	.....	13.3	do	Mar. 3

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of river bank.
					Least.	Greatest.	Average.	
	Corinne:	*Cu. yds.*	*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 3	16,898.47	14.74	$2,490.21	135	230	200	Making.
2	Section 4	20,283.37	14.74	2,989.77	110	200	160	Do.
3	Section 5	16,221.11	14.74	2,390.99	97	190	150	Stationary and washing.
	Story to Caernarvon:							
4	Section 3	22,507.78	14.45	3,252.87	140	430	330	Washing.
5	Section 4	23,346.28	14.45	3,373.54	115	215	150	Do.
6	Poydras, section 1.	14,668.53	14.90	2,175.61	240	450	350	Do.
7	Caernarvon, section 1.	14,496.46	16	2,319.43	245	420	310	Caving.

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Fourth district levees, 1898–99—Continued.

LAKE BORGNE LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Corinne:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	972.5	L.	George Jurgens	3,700	3,510	2.9
2	Section 2	973	L.	do	3,300	3,142	2.9
3	Poydras, section 2.	978	L.	John F. Meyer	2,810	2,150	2.9
	Caernarvon:						
4	Section 2	978.5	L.	Thos. Egan, jr	600	450	2.9
5	Section 3	978.5	L.	do	650	450	2.9
6	St. Clair	982	L.	Chas. G. Daunoy	9,640	10,219	2.8
7	Mon Plaisir	984	L.	do	5,300	5,188	2.8
8	Bertrandville	991	L.	do	400	400	2.2

No.	Name of levee.	Section.			New or enlargement.	Average height.		Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Corinne:	*Feet.*				*Feet.*	*Feet.*	1898.	*Cu. yds.*
1	Section 1	8	3 to 1	3 to 1	Enlargement	1.4	11.0	Oct. 22	15,163.16
2	Section 2	8	3 to 1	3 to 1	do	1.8	10.7	do	15,408.00
3	Poydras, section 2.	8	3 to 1	3 to 1	do	2.0	13.3	do	12,698.66
	Caernarvon:								
4	Section 2	8	3 to 1	3 to 1	New		13.3	do	12,950.24
5	Section 3	8	3 to 1	3 to 1	do		13.2	do	14,790.94
								1896.	
6	St. Clair	8	3 to 1	3 to 1	Enlargement	2.2	7.3	Oct. 26	47,037.45
7	Mon Plaisir	8	3 to 1	3 to 1	do	1.6	8.0	do	19,635.13
8	Bertrandville	8	2½ to 1	3 to 1	do	0.3	5.3	do	772.20

No.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of river bank.	Condition of contract.
			Least.	Greatest.	Average.		
	Corinne:	*Cents.*	*Feet.*	*Feet.*	*Feet.*		
1	Section 1	14.74	110	630	320	Making	Nothing done.
2	Section 2	14.74	112	200	142	do	35 per cent completed.
3	Poydras, section 2	14.90	245	420	310	Washing and caving.	33 per cent completed.
	Caernarvon:						
4	Section 2	16	350	370	360	Caving	83 per cent completed.
5	Section 3	16	340	355	350	do	Nothing done.
6	St. Clair	11.40	80	655	400	Washing and making.	72 per cent completed.
7	Mon Plaisir	11.40	122	242	190	Washing	Nothing done.
8	Bertrandville	12.00	60	60	60	Making	Do.

Summary of levees built from May 1, 1898 to May 1, 1899.

	Lower Tensas Levee district.	Atchafalaya Levee district.	Lafourche Levee district.	Barataria Levee district.	Pontchartrain Levee district.	Lake Borgne Levee district.	Total.
Earthwork...cubic yards	1,007,018	701,110.75	177,748.02	64,855.57	385,773.25	128,422.00	2,458,497.53
Embankment..linear feet	62,726	59,606	27,840	11,702	41,618	20,029	223,521
Axis of river covered, linear feet	47,146	58,360	28,000	11,747	35,673	17,110	198,036

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Statement of yardage of levee work constructed by the United States and others in the Fourth district, Mississippi River.

	Levee districts.					
	Lower Tensas.	Atchafalaya.	Lafourche.	Barataria.	Pontchartrain.	Lake Borgne.
Aggregate number of cubic yards in levees on the Mississippi River May 1, 1898	*Cub. yds.* 14,309,670	*Cub. yds.* 15,279,042	*Cub. yds.* 6,805,287	*Cub. yds.* 2,379,813	*Cub. yds.* 11,961,954	*Cub. yds.* 2,635,922
Added by the United States up to May 1, 1899	1,007,018	701,110	177,748	64,855	385,773	128,422
Added up to May 1, 1899, by State and district levee boards	48,821	760,619	21,141	35,713	125,965	85,232
Total	15,365,509	16,740,771	7,004,126	2,480,381	12,473,692	2,849,576
Lost by abandonment from May 1, 1898, to May 1, 1899:						
By the United States	103,437	38,600	.....	9,007	.....	5,400
By the State and others	35,000	174,783	135,404	15,347	29,920	9,433
Aggregate remaining May 1, 1899	15,227,072	16,527,388	6,868,722	2,456,027	12,443,772	2,834,743

Percentage of length of existing levee system, built in whole or in part by the United States.

Name of district.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Lower Tensas Levee district	47	52	52	59	63	66	72
Atchafalaya Levee district	8	16.8	43	47	68	65	67
Lafourche Levee district	6.5	14.4	28.8	54	61	61	62
Barataria Levee district	5.5	12.8	19.4	30	43	50	54
Pontchartrain Levee district	18	34.6	43.3	63	74	75	77
Lake Borgne Levee district	3.8	10.2	18	53	60	65	66

Percentage of total length of existing levee system, Fourth district, Mississippi River improvement, built in whole or in part by the United States.

	Per cent.		Per cent.
1893	13.8	1897	63
1894	26.2	1898	65
1895	36.6	1899	66
1896	52		

The amount expended from June 30, 1898 to June 30, 1899, is $232,963, distributed as follows:

Office expenses (main office)		$3,919.66
Other administrative expenses		9,791.91
Construction of levees (contracts)		122,141.56
Repairs to levees		3,147.89
Surveys		1,615.31
Repairs to plant		133.31
Care of plant		1,247.19
New plant		1,543.65
Protection of levees		1,070.67
Total		144,611.15
Emergency work at Kempe Levee:		
Administrative expenses	$3,599.28	
Subsistence	4,548.09	
Cost of quarters	2,255.29	
Hire of teams, laborers, etc	59,639.86	
Day labor	15,136.51	
Repairs to plant	14.45	
Station men (yardage, at 25 cents)	1,559.42	
Miscellaneous	1,598.95	
		88,351.85
Total		232,963.00

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Money statement.

LOWER TENSAS LEVEE DISTRICT.

July 1, 1898, balance unexpended		$134,681.91
Amount allotted since		158,000.00
March 9, 1899, amount allotted from appropriation, sundry civil act, March 3, 1899		217,300.00
		509,981.91
June 30, 1889, amount expended during fiscal year		232,963.00
July 1, 1899, balance unexpended		277,018.91
July 1, 1899, outstanding liabilities	$294.24	
July 1, 1899, amount covered by uncompleted contracts	44,345.94	
		44,640.18
July 1, 1899, balance available		232,378.73

The amount expended from June 30, 1898, to June 30, 1899, is $118,598.60, distributed as follows:

Office expenses (main office)	$3,095.07
Other administrative expenses	8,550.31
Construction of levees (contracts)	99,028.18
Repairs to levees	4,439.31
Surveys	171.39
Repairs to plant	194.78
Care of plant	70.36
New plant	3,049.20
Total	118,598.60

Money statement.

ATCHAFALAYA LEVEE DISTRICT.

July 1, 1898, balance unexpended		$107,835.32
Amount allotted since		87,000.00
March 9, 1899, amount allotted from appropriation sundry civil act of March 3, 1899		98,800.00
		293,635.32
June 30, 1899, amount expended during fiscal year		118,598.60
July 1, 1899, balance unexpended		175,036.72
July 1, 1899, outstanding liabilities	$352.37	
July 1, 1899, amount covered by uncompleted contracts	21,868.87	
		22,221.24
July 1, 1899, balance available		152,815.48

The amount expended from June 30, 1898, to June 30, 1899, is $28,776.05, distributed as follows:

Office expenses (main office)	$2,068.35
Other administrative expenses	3,218.82
Construction of levees (contracts)	21,420.79
Repairs to plant	22.64
Care of plant	3.00
New plant	2,042.45
Total	28,776.05

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Money statement.

LAFOURCHE LEVEE DISTRICT.

July 1, 1898, balance unexpended		[1] $44,080.05
March 9, 1899, amount allotted since		36,000.00
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899		37,050.00
		117,130.05
June 30, 1899, amount expended during fiscal year		28,776.05
July 1, 1899, balance unexpended		88,354.00
July 1, 1899, outstanding liabilities	$34.33	
July 1, 1899, amount covered by uncompleted contracts	38,284.46	
		38,318.79
July 1, 1899, balance available		50,035.21

The amount expended from June 30, 1898 to June 30, 1899, is $15,114.49, distributed as follows:

Office expenses (main office)	$504.92
Other administrative expenses	3,263.78
Construction of levees (contracts)	6,918.53
Repairs to levees	2,185.72
Surveys	130.91
Repairs to plant	.75
New plant	1,531.75
Protection of levees	578.13
Total	15,114.49

Money statement.

BARATARIA LEVEE DISTRICT.

July 1, 1898, balance unexpended		$21,199.53
Amount allotted since		27,000.00
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899		24,700.00
		72,899.53
June 30, 1899, amount expended during fiscal year		15,114.49
July 1, 1899, balance unexpended		57,785.04
July 1, 1899, outstanding liabilities	$125.80	
July 1, 1899, amount covered by uncompleted contracts	21,856.81	
		21,982.61
July 1, 1899, balance available		35,802.43

The amount expended from June 30, 1898, to June 30, 1899, is $63,378.33, distributed as follows:

Office expenses (main office)	$2,599.52
Other administrative expenses	5,160.20
Construction of levees (contracts)	50,492.12
Repairs to levees	4,259.57
Surveys	84.56
Repairs to plant	137.33
New plant	558.00
Protection of levees	84.38
Miscellaneous	2.55
Total	63,378.33

[1] Balance unexpended July 1, 1898, as stated in previous report, $44,055.05; difference due to disallowance of $25 in expenditures.

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Money statement.

PONTCHARTRAIN LEVEE DISTRICT.

July 1, 1898, balance unexpended		$73,254.27
Amount allotted since		76,000.00
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899		74,100.00
		223,354.27
June 30, 1899, amount expended during fiscal year		63,378.33
July 1, 1899, balance unexpended		159,975.94
July 1, 1899, outstanding liabilities	$524.00	
July 1, 1899, amount covered by uncompleted contracts	16,646.43	
		17,170.43
July 1, 1899, balance available		142,805.51

Balance unexpended July 1, 1898, as stated in previous report, $75,250.22; difference due to disallowance of $4.05 in expenditures.

The amount expended from June 30, 1898, to June 30, 1899, is $25,537.72, distributed as follows:

Office expenses (main office)	$508.04
Other administrative expenses	1,791.98
Construction of levees (contracts)	20,058.57
Repairs to levees	1,535.56
Surveys	108.32
Repairs to plant	5.75
New plant	1,529.50
Total	25,537.72

Money statement.

LAKE BORGNE LEVEE DISTRICT.

July 1, 1898, balance unexpended		$22,365.06
Amount allotted since		24,000.00
March 9, 1899, amount allotted from appropriation sundry civil act March 3, 1899		24,700.00
		71,065.06
June 30, 1899, amount expended during fiscal year		25,537.72
July 1, 1899, balance unexpended		45,527.34
July 1, 1899, outstanding liabilities	$12.64	
July 1, 1899, amount covered by uncompleted contracts	15,088.88	
		15,101.52
July 1, 1899, balance available		30,425.82

The following maps and appendices accompany this report:

Plate I. Natchez and Vidalia harbors.
Plate II. New Orleans Harbor (Algiers Point).
Plate III. New Orleans Harbor (Carrollton Bend).
Plate IV. Lower Tensas and Homochitto Levee districts.
Plate V. Atchafalaya, Lafourche, and Pontchartrain Levee districts.
Plate VI. Barataria and Lake Borgne Levee districts.
Appendix A. Statement of value of plant.
Appendix B. Commercial statistics.
Appendix C. List of civilian engineers.
Appendix D. Report of H. S. Douglas, assistant engineer, on Natchez and Vidalia harbors.
Appendix E. Report of H. S. Douglas, assistant engineer, on New Orleans Harbor.
Appendix F. Report of H. S. Douglas, assistant engineer, on repairs to plant.
Appendix G. Report of A. F. Woolley, jr., assistant engineer, on Atchafalaya and Red rivers, Louisiana.
Appendix H. Report of W. J. Hardee, assistant engineer, on levees.
Appendix I. Abstract of proposals.
Appendix J. Abstract of contracts in force.

Very respectfully, your obedient servant,

GEO. MCC. DERBY,
Major, Corps of Engineers.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

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APPENDIX 4 A.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, Fourth district, May 1, 1899.

Class of property.	Value.	Class of property.	Value.
Steam launch Ruby	$2,700.00	Forty-eight skiffs	$500.00
Tug General Comstock	6,000.00	Tools and appliances	20,000.00
Tug Tilda	2,600.00	Office furniture	3,500.00
Dredge The Ram	40,500.00	Surveying intruments	4,000.00
One pile driver	900.00	Drawing instruments	200.00
Five quarter boats	11,700.00	Railway cars and track	1,000.00
Twenty-five barges	36,000.00		
One warehouse barge	500.00	Total	132,000.00
One dry dock	900.00		

APPENDIX 4 B.

Foreign commerce, port of New Orleans.

The statistics relating to the foreign commerce of the port of New Orleans were kindly furnished by Hon. A. T. Wimberly, collector of customs.

Vessels.	Entrances.			Clearances.		
	1896-97.	1897-98.	1898-99.	1896-97.	1897-98.	1898-99.
Steam	1,236	1,282	1,198	1,232	1,287	1,207
Sail	72	65	126	56	61	112
Total	1,308	1,347	1,324	1,288	1,348	1,319

Total tonnage of above.

1896-97	3,774,688
1897-98	4,236,663
1898-99	3,848,736

Exports and imports.

	1897.	1898.	1899.
Exports:			
Total value of exports of foreign merchandise to foreign countries	$303,319.00	$546,378.00	$1,394,140.00
Total value of exports of domestic merchandise to foreign countries	98,513,917.00	104,965,121.00	89,803,442.00
Total	98,817,236.00	105,511,499.00	91,107,582.00
Imports:			
Total value of imports from foreign countries—			
Free	9,357,466.00	5,916,768.00	4,528,576.00
Dutiable	5,409,332.00	5,934,902.00	5,580,950.00
Transit to Mexico	921,015.00	949,070.00	.....
Transported to interior ports	1,184,048.00	811,427.00	.....
Specie	615,571.00	539,344.00	585,792.00
Total	17,487,432.00	14,151,511.00	10,695,318.00
Total duties collected	2,039,146.78	2,200,275.44	2,682,385.12

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APPENDIX 4 C.

List of civilian engineers employed on work of river and harbor improvements, Fourth district, improving Mississippi River, from May 1, 1898, to May 1, 1899, in charge of Maj. Geo. McC. Derby, Corps of Engineers.

Name and residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	Months.			
H. S. Douglas, New Orleans, La.	1 8/30 11 7/30	$300 225	Natchez, Miss., and New Orleans, La.	Improving harbors at Natchez Miss., and Vidalia, La. Improving harbors at New Orleans, La.
W. J. Hardee, New Orleans, La.	7 3/3	225	New Orleans, La.....	Levees, Lower Tensas, Atchafalaya, Lafourche, Barataria, Pontchartrain, and Lake Borgne Levee districts.
William Starling, New Orleans, La.	7 1/3	225	.....do	Do.
E. B. Geddes, Natchez, Miss.	12	150	Natchez, Miss	Improving harbors at Natchez, Miss., and Vidalia, La.
A. F. Woolley, jr., New Orleans, La.	12	150	New Orleans, La., and Old River, Louisiana.	Surveys, gauges, and observations, improving Atchafalaya and Red Rivers, Louisiana.

APPENDIX 4 D.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER, IN LOCAL CHARGE OF IMPROVING HARBORS AT NATCHEZ, MISS., AND VIDALIA, LA.

NEW ORLEANS, LA., *May 1, 1899.*

SIR: I have the honor to submit the following report on the work of improving the harbors at Natchez, Miss., and Vidalia, La., for the period from May 1, 1898, to date:

At date of last report, 15 spur dikes containing 682,900 square feet of mattress and 816,000 cubic feet of cribs had been placed in Giles Bend, covering about 7,060 linear feet of bank. The river was still at a high stage, but the work appeared to be generally in good condition and accomplishing the purpose for which it was designed. The plant was moored to the bank near the head of Giles Bend, and in readiness to resume work when the river had fallen to a sufficiently low stage.

During the high-water season estimates of material required for a continuation of spur-dike construction were made, proposals asked, contracts made, and delivery commenced, except for rock. The award of contract for this latter article was not approved until about January 13, 1899, and even if there had been no other cause this would have prevented extensive work during the past season in Giles Bend. The delay in approval of contract for rock made but little difference, for even if award had been made in time, quarantine restrictions, which virtually suspended all public means of transportation, would have prevented its delivery until too late to have accomplished much work.

A large pump was taken off the tug *Tilda* and installed in a small barge built for the purpose, and the boiler formerly on the condemned launch *Alaska* placed in the barge. This pump boat was intended to furnish water for sluicing purposes while grading the bank. The old boiler on the pile driver No. 32 was taken out and replaced by the boiler formerly on the condemned dredge *Pah Ute*. The leads were altered and equipped with a steam hammer borrowed from works under charge of Maj. James B. Quinn.

For various reasons, but principally on account of extreme high water and the scarcity of labor, it was not until September 8 that it was considered advisable to commence construction. The willow bar just below L'Argent Landing, La., had been selected as the locality for cutting willows and constructing mattresses and cribs. On September 8 the quarter boats *New Orleans* and *Delta*, a barge of lumber and other material, a fuel barge, and the tug *Comstock* were moved from Giles Bend to L'Argent and construction commenced. In order to obtain a force, nearly all of the men engaged in building mattresses and cribs for New Orleans Harbor at Cowpen Bend were transferred to the plant at L'Argent.

From commencement to conclusion the history of the past season's work is one of disaster and disappointment. Lack of labor, continued high stage of the river, unfavorable weather, suspension of communication on account of yellow fever, as

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well as all sorts of minor troubles incident to work of this character, either succeeded each other or were all in existence at the same time.

On September 26, the Natchez gauge being 16 feet above low water, the condition of the work in Giles Bend was as follows: Spurs 1, 2, and 3 were in good condition. At Spurs 4, 5, 6, and 7 the graded and paved bank had been injured and the bank line between the spurs caved considerably. At Spur 8 the shore end of the mattress and crib appeared to have gone, the graded and paved bank had disappeared, and some of the piling had washed out, while the earth had washed away from around those that remained. Spurs 9, 10, 11, and 12 were in good condition, but the graded and paved bank at Spurs 13, 14, and 15 was somewhat injured. Considerable caving had occurred immediately below Spur 8 and between Spurs 14 and 15. Later on a survey showed that from Spur 8 to 12 there had been a very great scour between the spurs, the scour in an extreme case being 40 feet. Nothing of this was apparent above the water surface.

Fortunately, as matters turned out, the scarcity of labor made construction at L'Argent Bar very slow. The river remained at a comparatively high stage, and as a consequence the mattresses and cribs afloat silted up very rapidly, so that by October 3 it became necessary to commence sinking. The caving below Spur 8 meanwhile had continued, and it was decided to put another spur immediately below and possibly one above. Accordingly the plant was hastily swung into position and the foundation mattress for Spur 8¼ sunk in place, the upper edge overlapping the mattress of Spur 8, if that mattress is still in place, which is not certain. The crib work was completed by October 8, but on account of lack of labor the grading of the bank was not finished until November 1 and the paving not completed until January 3. The pavement of the bank at this spur is of brick laid on edge and extends 50 feet above the center line and 100 feet below. Its condition after the subsidence of the present high water, both as to the effect of increased width or length of paved bank and as to the suitability of brick for this purpose, will be observed with great interest.

On October 7 quite unexpectedly yellow fever was declared to exist in Natchez, the nearest base of supplies and the principal source from which labor was obtained. The effect was demoralizing in the extreme. Enough labor to load rock from the small supply left over from last season's work could not be obtained, and as a result three cribs were lost by silting up and sinking before arrangements to sink them in place on a spur could be made. A similar fate for three sections of completed mattress intended for the foundation of a new spur between 7 and 8 was avoided to some extent by mooring them near the bank immediately below Spurs 5, 6, and 14, where they first sunk of their own accord and were afterwards ballasted with stone when sufficient labor to load and place it could be had. These sections, containing 15,000 square feet each, can not be considered lost, as they will serve to counteract the effect of eddy action below the spurs and may become part of a continuous revetment.

Of course further construction of mattresses and cribs at the Willow Bar below L'Argent was suspended. Some correspondence with labor agents in the earlier portion of the season was had, but these agents stated that they could not induce men to come to a country where yellow fever prevailed. The labor on hand disappeared, for, no matter how comfortably quartered nor how well fed, the average man, either white or black, dislikes the idea of being practically a prisoner to such an extent that he takes the first opportunity to escape. As an illustration of this, some of the employees made the trip of nearly 300 miles from L'Argent to New Orleans in an open skiff rather than remain on the quarter boat, to which they were practically confined. Such labor as remained in Giles Bend, where an endeavor to sink the mattresses and cribs that had been built was made, of course struck for an increase of wages, which, under the circumstances, was given.

On December 9 the work was inspected by the Mississippi River Commission, and on the 15th instructions were received modifying the project by directing that a standard revetment be placed between the mats under the existing spurs, and directing that no additional spurs in extension of the improvement were to be built until authorized by the Commission.

As there was not sufficient rock on hand to undertake this work, an emergency purchase of 3,000 tons was made. The correspondence incident to this purchase and to making arrangements as to time, manner, and place of delivery occupied considerable time. To have undertaken to build mattresses until there was a reasonable certainty of obtaining rock wherewith to sink them would have been unwise, so it was not until January 3 that construction was recommenced at L'Argent. On that date the Natchez gauge read 18.6. On January 18 the river had risen to 30.5 on the same gauge, and had encroached on the Willow Bar to such an extent as to partially submerge the ways. The indications were that the river would continue to rise, and construction was therefore suspended for the season.

The current and drift in Giles Bend made it impracticable to sink the mattresses built between the spurs as a continuous revetment, but as continued caving of the

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bank above Spurs 5 and 7 threatened to flank these spurs it was decided to endeavor to sink two sections of mattress against the bank immediately above them.

On account of the high stage of the river, it was only after several failures that the sections were finally landed and placed in the desired positions, where it was hoped they would prevent further erosion of the bank between high and low water. The two sections, each containing 16,000 square feet, were ballasted with rock and sunk by January 31, on which date, the Natchez gauge reading 38.2, all work was suspended. Other sections of mattress that had been completed at L'Argent were towed down the river nearly 300 miles, turned over to and utilized for the Southport work at the upper end of New Orleans Harbor, where sinking was in progress. I wish to call especial attention to this, as it is a practical illustration of one of the advantages claimed for the style of mattress in use in this district. With almost any other kind of willow mattress it would have been an impossibility to have towed them this long distance and they would have been lost.

Considering the foregoing general history of the season's work, it is not surprising that the cost was excessive. In the work of the two previous seasons, New Orleans Harbor in 1896–97 and Giles Bend in 1897–98, one or two of the conditions may have been unfavorable, but in the work just described they were all unfavorable.

At L'Argent Bar, where the mattresses and cribs were built, two sets of ways were constructed, but on account of scarcity of labor and high stage of the river but one set was used to any extent. The cost of these ways in detail was:

2,640 feet B. M. 2 by 4 inch lumber, at $9	$23.76
15,137 feet B. M. 3 by 6 inch lumber, at $9	136.23
4,874 feet B. M. miscellaneous lumber, at $9	43.86
50 pounds 9-inch steel-wire nails, at $1.58	.79
600 pounds 6-inch steel-wire nails, at $1.48	8.88
100 pounds 4-inch steel-wire nails, at $1.48	1.48
Labor and superintendence	231.39
Subsistence, including service	121.45
Total	567.84

The L'Argent Bar, where the willows were cut, is not a particularly good one on account of long haul. Its use was almost compelled by the high stage of the river.

Unfavorable weather and suspension and recommencement of work also added to the cost, which was:

Cutting, loading, and unloading	$996.44
Hauling	593.52
61.62 acres of land, at $1	61.62
Subsistence, including service	548.00
Total	2,199.58
Cords of brush and poles used on mattress	1,275
Cords of brush and poles used on cribs	425
Total	1,700
Cost per cord delivered at ways	$1.29 $\frac{38}{100}$

The comparatively small number of men employed, together with the circumstances heretofore described, increased the cost of subsistence, which was:

Provisions, including freight, ice, etc	$2,779.20
Service	990.96
Total	3,770.16
Number of men subsisted	9,500
Cost of raw ration	$0.2925
Cost of served ration	.3969
Cost of ration per day's labor secured	.5200

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The total cost of constructing the mattresses and cribs, including installation, building ways, etc., was $8,612.22, divided as follows:

Mattress.

44,227 feet B. M. 2 by 4 inch lumber, at $9	$398.05
21,937 feet B. M. 3 by 6 inch lumber, at $9	197.43
3,257 feet B. M. miscellaneous lumber, at $9	29.31
550 pounds No. 10 galvanized wire, at $1.80	9.90
1,925 pounds 9-inch steel-wire nails, at $1.58	30.41
4,200 pounds 6-inch steel-wire nails, at $1.48	62.16
1,000 pounds 4-inch steel-wire nails, at $1.48	14.80
Miscellaneous, oils, fuel, etc	209.44
Labor, superintendence, etc	3,594.42
Subsistence, including service	1,871.70
Total	6,417.62
Square feet of mattress built	122,000
Cost per square foot at ways	$0.05265

Cribs.

880 feet B. M. 2 by 4 inch lumber, at $9	$7.92
22,226 feet B. M. 3 by 6 inch lumber, at $9	200.03
2,960 feet B. M. miscellaneous lumber, at $9	24.21
150 pounds No. 10 galvanized wire, at $1.80	2.70
2,075 pounds 9-inch steel-wire nails, at $1.58	32.78
700 pounds 6-inch steel-wire nails, at $1.48	10.36
Miscellaneous, oils, fuel, etc	100.00
Labor, superintendence, etc	1,192.70
Subsistence, including service	623.90
Total	2,194.60
Cubic feet of crib work	84,000
Cost per cubic foot at ways	$0.02612

Willow brush and poles are included in the cost of labor and subsistence, as these two items are the principal expense.

The distance between where the mattresses and cribs were built at L'Argent and Giles Bend, where they were sunk, is only 8 miles. For this reason no separate cost is given for towing, this expense being included in the cost of construction and sinking.

The total cost of sinking the mattresses and cribs was $4,414.79, divided as follows:

Mattress.

639 tons rock, at $1.64	$1,047.96
Miscellaneous, oils, fuel, etc	400.65
Labor, superintendence, etc	1,368.36
Subsistence, including service	714.56
Total	3,531.53
Square feet of mattress sunk	122,000
Cost per square foot in sink	$0.02894
Total cost per square foot in place	$0.08159

Cribs.

159 tons of rock, at $1.64	$260.76
Miscellaneous. oils, fuel, etc	95.00
Labor, superintendence, etc	341.50
Subsistence, including service	186.00
Total	883.26
Cubic feet of cribs sunk	52,800
Cost per cubic foot to sink	$0.01672
Total cost per cubic foot in place	$0.05640

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These figures are high, but in my opinion the cribs that silted up and were lost are a proper charge against the work, and their cost is included in the figures given. Omitting them, the cost of cribs in place per cubic foot would be $0.04284.

During the season surveys were made to ascertain the condition of the spurs and the changes going on in Giles Bend. The extent of these surveys can best be seen from the following summary:

Length of base line cut out	miles..	8
Length of bank line meandered	do....	3
Length of offset or ordinate lines measured	do....	10
Number of sections sounded, about		75
Cost of labor and superintendence		$596.42
Subsistence, including service		164.00
Total		760.42

Delivery of the long-delayed rock commenced in March, and at date of this report 8,139.52 tons delivered on Government barges at Vidalia, La., had been towed to Giles Bend and unloaded on the bank for use when required for bank protection work.

The towing has all been done by one small tug, the *Tilda*, which has made the remarkable record of moving this amount of rock 18 miles upstream during high water without accident or mishap.

At close of this report, so far as can be seen at the present stage of the river, no material change has occurred in that portion of the bank protected by spurs. At the lower end of Giles Bend, near the end of the spur levee on Cowpen Neck, caving has been very active, and it is quite probable that the outer end of the levee will be breached before the high water of 1900. The plant is in lying-up quarters and in readiness for active work when the river falls sufficiently. About 3,000 tons more rock is to be delivered during the month of August, when it is hoped to save an extra handling of this amount by unloading it directly from the barges on the mattress or shore paving. Some other material, in the way of lumber and wire nails, is also on hand.

Assistant Engineer E. B. Geddes has been resident on the work, and as heretofore has rendered the most valuable services during the unfavorable conditions under which the work was prosecuted.

Very respectfully, your obedient servant,

H. S. DOUGLAS, *Assistant Engineer.*

Maj. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 4 E.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER, IN LOCAL CHARGE OF IMPROVING HARBOR AT NEW ORLEANS, LA.

NEW ORLEANS, LA., *May 1, 1899.*

SIR: I have the honor to submit the following report on the work of improving the harbor at New Orleans, La., for the period from May 1, 1898, to date:

At date of last report the condition of the work done in previous years was generally good. A project for the protection of the bank at Algiers Point, by submerged sloping spur dikes, had been approved. This project provided that the interval between the spurs should be about 450 feet; that the foundation mattress should be 150 by 400 feet, and that where the slope of the bank between spurs exceeded 2½ to 1, two short buttress spurs, built of two cribs without a foundation mattress, should be placed. The general methods of construction were the same as in previous years.

During the season of 1897–98 no construction was undertaken, as all of the available plant of the district was engaged on bank protection work in Giles Bend, improvement of the harbors at Natchez, Miss., and Vidalia, La.

The high-water period of 1898 was utilized in putting the plant in order and in making arrangements to obtain the necessary material for spur-dike construction. A new feature was the purchase of 3,238 tons of brick as a substitute for rock in ballasting the mattresses and cribs.

On August 20, although the river was unusually high for the season, it was decided to commence construction. Accordingly the quarter boat *Gamma*, with two barges

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of material and the pump boat, left the Government depot in tow of the tugs *General Comstock* and *Tilda* for Cowpen Bend, immediately above Natchez, where it had been decided to build the mattresses and cribs. There were several reasons for selecting a location so far up the river. The plant was limited, and as it had been decided to carry on both the New Orleans Harbor and Natchez Harbor works simultaneously, it was necessary to keep the two works close enough together, so that the deficiencies of one work could be quickly supplied from the other. There was also the advantage of both being immediately under the supervision of the assistant engineer. Another reason was, that from experience in the past it was known that below Red River, in the summer and early fall, labor is scarce, while in the vicinity of Natchez there is, or was, a local labor force of about 200 men that could be had. Northern labor does not commence to come south before October 1, and not then if there is any prevailing sickness and quarantines. As matters turned out, this local labor was all we ever had, and it is probable that had the work been located farther down the river, say in the vicinity of Bayou Sara or Baton Rouge, nothing would have been accomplished.

The plant arrived at Cowpen Bend on August 26, and construction of ways was immediately commenced. Labor was exceedingly scarce, and it was not until August 29 that sufficient men were available to commence cutting willows, to say nothing of commencing mattress and crib construction. Meanwhile yellow fever had developed in New Orleans, and on account of quarantine restrictions the situation had become complicated and uncertain. I proceeded to Vicksburg, and after a conference with the officer in charge it was decided that in view of the uncertainty of the situation and the scarcity of labor it was inexpedient to attempt to push construction on New Orleans Harbor until the conditions had further developed. Accordingly the small force that had with difficulty been accumulated were transferred to the willow bar, just below L'Argent Landing, to build mattresses and cribs for the Giles Bend spur dikes. A few men were retained at Cowpen Bend to extend the ways as the river fell, to build a third set of ways, construct frames, and otherwise have everything in readiness to push construction to the limit whenever the conditions permitted. Instead of the situation improving, it grew steadily worse, and on October 4 all work was suspended.

As stated, the plant was insufficient to carry on two works to advantage, this insufficiency being especially marked in the matter of steam craft. For this reason the steamer *Thomas B. Florence* was temporarily transferred to the works of improvement under my local charge. She arrived at Cowpen Bend on August 31. On September 10 she was sent to New Orleans to tow up barges loaded with additional material for the works. While on her way back, quarantine was declared, and it was not certain that the *Florence* would be permitted to return. This was one of the numerous reasons why it was not practicable to build mattresses and cribs, as there was no boat available for towing them to New Orleans. I finally succeeded in obtaining permission for the *Florence* to return with her tow, and after a slight detention in quarantine, she arrived in Cowpen Bend on October 1. Negotiations were also opened with the health officials with a view to having a representative placed on the *Florence* to see that their regulations were observed and permit her to tow to and from New Orleans. These negotiations promised success, when suddenly, on October 7, yellow fever developed in Natchez. This practically put a stop to everything. During the year 1897 public transportation and communication were greatly hampered by quarantines; but in 1898 they were practically stopped. For a considerable period, perhaps ten days, even the mail service was suspended. The difficulty of obtaining supplies and material might have been overcome by the United States establishing their own means of transportation, but laborers will not come to a country where they can not go where they please. Even if laborers are obtained by offering high wages, furnishing transportation, etc., they will not remain on the works any length of time, because they must of necessity be confined to a desolate willow bar, and can not go and come at will from the nearest town or settlement. I have enlarged somewhat on this subject because the temporary suspension of work on New Orleans Harbor was a matter of public and unfavorable comment. This is because the distinction between impracticable and impossible is not generally understood. Few things are impossible, while many are impracticable. By the expenditure of large sums of money men could have been obtained and supplied so that work would not have been suspended. Did the emergency justify this? I think not. Therefore it was impracticable. It is generally regarded as impracticable to undertake bank protection during high water, but it is not impossible.

To state the case briefly, from September 8 to November 4, practically two months, all work was suspended. On November 4 the situation had so far improved that I decided to recommence work, and from that day until stopped by high water, on January 18, construction of mattresses and cribs was pushed as rapidly as possible. Continued scarcity of labor and heavy rains interfered greatly with the work and increased its cost.

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Considering the lateness of the season it was reasonably certain that it would be impossible to build all of the eleven spur dikes projected for the Algiers Point. It was therefore decided to complete Nos. 12, 13, 14, 15, 16, and 17, covering that portion of the bank where work was considered the most urgent. At its meeting in December the Mississippi River Commission transferred $12,000 from the Algiers Point work to the protection of the upper end of the Carrollton Bend, now known as Southport. The projected work consisted of additional mattresses between spurs 3 and 4, around and under the long railroad wharf. This was additional work that had not been contemplated, but it was completed, except the mattressing under the wharf, which could not be placed on account of high water.

On November 17 construction of mattresses was so far advanced that it was decided to commence towing them to New Orleans. Experience had proved that the steamer *Florence* was not adapted for this purpose, so the stern-wheel towboat *Belle Prince* was chartered and a double crew placed on her. She left with her first tow, consisting of 120,000 square feet (2¾ acres) of mattresses, on November 18. On the day following the quarter boat *Gamma*, in tow of the *Tilda*, was dispatched to New Orleans to organize a force, load rock, and make preparations for sinking the spurs. She arrived on November 22. In the meanwhile the *Belle Prince* was making slow progress with her tow and the *Tilda* was sent to help her. The tow arrived on November 28 after a stormy experience. As the owner of the *Belle Prince* said that his boat would have to go on the dock for repairs, the *Tilda* was dispatched to Natchez November 30 with the intention of having her help the *Florence* down with the next tow. In the meanwhile the owner of the *Belle Prince* decided he could make another trip, and the boat returned to Natchez on December 2 and left the next day with a tow containing 252,864 cubic feet of cribs.

The *Tilda* thus being absent, the tug *Baton Rouge Belle* was chartered, and on December 3 the plant was moved to Algiers Point. On December 7 the barges were swung into position for sinking on Spur No. 15. The first mattress was sunk on December 8 and the last crib placed January 17, the actual working time being 35 days. The sinking could have been done in less time but for the failure of tows to arrive when needed. The total quantity of mattresses placed on the six spurs was 360,000 square feet, and of cribs, 586,800 cubic feet.

On December 7 the *Tilda*, after assisting the *Belle Prince* as far as Bayou Sara, returned to New Orleans, and the services of the chartered tug were dispensed with. On December 24 the owners of the *Belle Prince* withdrew their boat, and the experience of towing the mattresses and cribs with a stern-wheel boat having been rather discouraging, it was decided to place double crews on the Government tugs *General Comstock* and *Tilda* and put them on the long-distance towing. Accordingly, the tug *Baton Rouge Belle* was again chartered for local work in sinking the mattresses and cribs and the *Tilda* sent up to Cowpen Bend for a tow. The two Government tugs continued on this service until January 28, when the last tow of mattresses arrived, and the services of the chartered tug were again dispensed with.

The foregoing facts will serve to explain why the cost of work during the past season has been unusually great. A constant endeavor was made to systematize the work, and this endeavor was persistently defeated by circumstances beyond control. Not the least of these was sickness among the employees. At one time the hospital at Natchez was so filled with our sick men that they could scarcely be accommodated.

Ways.—Three sets of ways were built in Cowpen Bend, partly with a view to decreasing the length of haul for the willow brush, and partly to push the work as rapidly as possible when sufficient labor could be obtained. At no time, however, was the force large enough to work all three sets of ways to advantage. The natural bank of the river in front of the willow bar was abrupt, instead of the usual flat slope, and a considerable amount of grading was necessary to obtain ways with a sufficiently flat slope. This increased the cost, which in detail was:

27,380 feet B. M., 3 by6 inch lumber	$260.11
7,000 feet B. M., miscellaneous lumber	70.00
1,400 pounds 6-inch steel wire nails	20.72
Labor, superintendence, etc	720.10
Subsistence	360.00
Total	1,430.93

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Willows.—Heavy rains made the roads over the willow bar very heavy and necessitated a great deal of work in the way of corduroying. Stalled teams, which had to be unloaded and reloaded, were of frequent occurrence, and as a natural consequence the quantity of willows per load were decreased and the cost increased.

Cutting, hauling, etc	$7,076.62
Subsistence, including service	1,998.90
About 165.77 acres land, at $1	165.77
Total	9,241.29
Number cords willows and poles used	7,825
Cost per cord delivered at ways	$1.1800
Cost per cord towing to New Orleans	0.5831
Cost, delivered at New Orleans	1.7631

Subsistence.—The cost of subsistence while building the mattresses and cribs was increased by the two months' practical suspension of work, during which time a small force had to be retained, and by the difficulty and expense of getting supplies, when the regular means of transportation were not available.

Provisions, including freight, ice, etc	$7,759.65
Service	2,137.47
Total	9,897.12
Number of men subsisted	24,800
Cost of raw ration	$0.3129
Cost, served	$0.3990
Cost per day labor secured	$0.5200

Construction.—The total cost of constructing the matresses and cribs, including installation, building ways, expense while work was suspended, etc., was $34,971.25, divided as follows:

Mattresses.

11,164 feet B. M., miscellaneous lumber	$111.64
162,781 feet B. M., 2 by 4 inch lumber	1,383.64
66,190 feet B. M., 3 by 6 inch lumber	628.80
4 800 pounds 9-inch steel wire nails, at $1.58	75.84
13,200 pounds 6-inch steel wire nails, at $1.48	195.36
2,500 pounds 4-inch steel wire nails, at $1.48	37.00
3,000 pounds No. 10 galvanized wire, at $1.80	54.00
Miscellaneous, oils, fuel, etc	593.44
Subsistence, including service	5,924 85
Labor, superintendence, etc	13,017.53
Total	22,022.10
Total square feet of mattress built	472,500
Cost per square foot for constructing	$0.0466

Cribs.

11,163 feet B. M., miscellaneous lumber	$111.63
145,625 feet B. M., 3 by 6 inch lumber	1,382.44
7,800 pounds 9-inch steel wire nails, at $1.58	123.24
2,400 pounds 6-inch steel wire nails, at $1.48	35.52
1,000 pounds No. 10 galvanized wire, at $1.80	18.00
Miscellaneous, oils, fuel, etc	419.67
Subsistence, including service	3,340.00
Labor, superintendence, etc	7,518.65
Total	12,949.15
Total cubic feet of cribs built	586,800
Cost per cubic foot for construction	$0.0220

Towing.—The cost of towing the cribs and mattresses to New Orleans was excessive, from a variety of reasons. During the entire period that towing was in progress the

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weather was either stormy or foggy, and the boats were compelled to go to the bank with their tows. The *Belle Prince*, leaving Cowpen Bend on the morning of November 18, did not arrive at New Orleans until the evening of the 28th, requiring two hundred and forty-eight hours to make 270 miles downstream, but little over 1 mile per hour. The actual time the boat was under way was eighty-six hours, or at the rate of 3.1 miles per hour. Some apprehension has been expressed about the mattresses being able to withstand accidents incidental to towing. On November 23, while en route, the machinery of the *Belle Prince* became disabled. The report of the master of the boat states that the tow was turned loose and "rolled," as he expressed it, the full length of Mulatto Bend. He verbally informed me that at times portions of the mattresses were pushed out high and dry on the bank and dragged over projecting points. The tow was finally caught and landed by the tug *Will H. Wood* at Mulatto Point. Notwithstanding this, and weather so stormy that the steamer did not venture out, the mattresses arrived safely at New Orleans and were sunk without having to be extensively repaired. No further proof of the seaworthiness, if I may so express it, of the mattresses seems to be necessary.

During the towing the most rapid trip made was by the tug *General Comstock*. She left Cowpen Bend on January 12, at 6 a. m., with 60,000 square feet of mattress, and landed at New Orleans at 4 a. m. on the morning of January 15, the total time being 70 hours, or at the rate of 3.8 miles per hour, including one stop for coal.

From the experience gained during the past season in towing it would seem that better results are obtained with tugs than with stern-wheel boats, but I am not prepared to express a final opinion on this subject until more extended experience has been had. My reasons for this are that the *Belle Prince* running time was but 86 hours, and she brought down 120,000 square feet of mattresses. The *Comstock* brought down 60,000 square feet of mattress in 70 hours. The total cost of the *Belle Prince* was about $60 per day of 24 hours. The total cost of the *Comstock* was about $37 per day of 24 hours. By a rough calculation it will be seen that on the basis of running time the cost of towing down 120,000 square feet with the *Belle Prince* was $210, while the cost of 60,000 square feet with the *Comstock* was $111, the difference being slight. Probably the best results would be obtained with a tug of, say, double the power of the *Comstock*, which could handle as large a tow as the *Belle Prince*. Such a boat would not have to go to the bank in stormy weather, but only in case of fog.

Three boats were engaged in the towing—the chartered steamer *Belle Prince* and the two Government tugs *General Comstock* and *Tilda*, and the total cost was $4,553.21, divided as follows:

Belle Prince, 37 days	$2,228.55
Tug *General Comstock*, 31 days	1,152.62
Tug *Tilda*, 30 days	1,172.04
Total	4,553.21

Total cost of towage with the *Belle Prince* was:

Per square foot of mattress	$0.00721
Per cubic foot of crib	$0.00351

The cost of towage with tugs *Comstock* and *Tilda* was:

Per square foot of mattress	$0.00624
Per cubic foot of crib	$0.00174

The average cost of towage from Cowpen Bend to New Orleans was:

Per square foot of mattress	$0.00652
Per cubic foot of crib	$0.00250

Sinking.—While the cost of the work up to the time of the arrival of the mattresses and cribs at New Orleans was excessive the same can not be said of the most difficult portion of the work, that of ballasting and sinking in the desired position. As this work was not commenced until December 3, long after the yellow-fever scare had subsided, labor was plentiful and efficient. The weather was good for the season of the year and no serious mishaps or accidents occurred.

As before stated, the quarter boat *Gamma* was used to quarter the force engaged in sinking the mattresses and cribs, and while the Government tugs were engaged on the long-distance towing the *Baton Rouge Belle* was chartered to handle the plant and place the mattresses and cribs between the lowering barges. Notwithstanding that the exigencies of the services necessitated the employment of comparatively inexperienced men, the sinking was prosecuted to the best advantage and in an economical manner, serving to offset to some extent the excessive cost of towage and construction.

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The cost of subsistence for the Algiers Point work was:

Provisions, including ice	$1,586.18
Service	429.50
Total	2,015.68

Number of men subsisted	6,075
Cost of raw ration	$0.2611
Cost served	$0.3318
Cost served per day labor secured	$0.4662

The first mattress was sunk on December 8, and all work on the six spurs and two buttresses completed January 23, the actual working time being 35 days, and the cost for labor and material $16,492.92.

The total cost per square foot of mattress in place was $0.07702, divided as follows:

Construction at Cowpen Bend	$0.04660
Towing, Cowpen Bend to New Orleans	.00652
Ballasting and sinking into position	.02390
Total	.07702

Total cost per cubic foot of cribs in place was $0.03790, divided as follows:

Construction at Cowpen Bend	$0.02200
Towing, Cowpen Bend to New Orleans	.00250
Ballasting and sinking into position	.01340
Total	.03790

As it has been customary to give details of the several spurs, I will continue to do so.

SPUR NO. 15.

The plant was placed into position December 7, and the foundation mattress sunk the next day. The last crib was sunk on December 14. The dimensions of the mattress were 150 by 400 by 2½ feet.

Square feet in mattress	60,000
Cords of willows and poles used	627
Tons of rock used	294.11
Tons of brick used	83.12
Pounds ballast per square foot to sink	12.57

The dimensions of the cribs were:

Crib No. 1, 24 by 56 by 6 feet.
Crib No. 2, 80 by 48 by 6 feet.
Crib No. 3, 144 by 40 by 6 feet.
Crib No. 4, 220 by 32 by 6 feet.
Crib No. 5, 268 by 24 by 6 feet.
Crib No. 6, 342 by 16 by 6 feet.

Cubic feet of cribs in spur	179,328
Cords of willows and poles used	879
Tons of rock used	127.3
Tons of brick used	397.75
Pounds ballast per cubic foot to sink	5.85

SPUR NO. 14.

The plant was swung into position December 15, the mattress sunk on the 17th, and the last crib on the 20th. The dimensions of the mattress on this and all the spurs were the same—150 by 400 by 2½ feet.

Square feet in mattress	60,000
Cords of willows and poles used	627
Tons of rock used	251.11
Tons of brick used	201.14
Pounds ballast per square foot to sink	15.07

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The dimensions of the cribs were:

Crib No. 1, 106 by 32 by 6 feet.
Crib No. 2, 178 by 24 by 6 feet.
Crib No. 3, 287 by 16 by 6 feet.

Cubic feet of cribs in spur	73,536
Cords of willows and poles used	360
Tons of rock used	148.67
Tons of brick used	162.97
Pounds ballast per cubic foot to sink	8.68

SPUR NO. 16.

The plant was swung into position December 26, and the foundation mattress sunk on the 28th. Owing to the nonarrival of the tow of cribs for this spur the plant was then moved to Spur 17, and again swung into position on No. 16 on January 3 and the last crib sunk on January 4.

Square feet in mattress	60,000
Cords of willows and poles used	627
Tons of rock used	233.2
Tons of brick used	191.7
Pounds ballast per square foot to sink	14.11

The dimensions of the cribs were:

Crib No. 1, 200 by 24 by 6 feet.
Crib No. 2, 300 by 16 by 6 feet.

Cubic feet of cribs in spur	57,600
Cords of willows and poles used	282
Tons of brick used	276.28
Pounds ballast per cubic foot to sink	9.59

SPUR NO. 17.

The plant was swung into position on December 29, and the mattress sunk on the 30th. The last crib was placed January 2.

Square feet in mattress	60,000
Cords of willows and poles used	627
Tons of rock used	179.59
Tons of brick used	197.62
Pounds ballast per square foot to sink	12.57

The dimensions of the cribs were:

Crib No. 1, 38 by 40 by 6 feet.
Crib No. 2, 150 by 32 by 6 feet.
Crib No. 3, 222 by 24 by 6 feet.
Crib No. 4, 300 by 16 by 6 feet.

Cubic feet of cribs in spur	98,688
Cords of willows and poles used	484
Tons of rock used	131.27
Tons of brick used	261.35
Pounds ballast per cubic foot to sink	7.96

SPUR NO. 13.

The plant was placed into position on January 9, and the mattress sunk on the 10th. Owing to the nonarrival of a tow of cribs the plant had to be moved to Spur No. 12, and was returned to Spur No. 13 on January 15. The last crib was sunk on January 20.

Square feet in mattress	60,000
Cords of willows and poles used	627
Tons of rock used	241.70
Tons of brick used	83.25
Pounds ballast per square foot to sink	10.83

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The dimensions of the cribs were:

Crib No. 1, 200 by 32 by 6 feet.
Crib No. 2, 247 by 24 by 6 feet.
Crib No. 3, 327 by 16 by 6 feet.

Cubic feet of cribs in spur	105,360
Cords of willows and poles used	516
Tons of rock used	123.19
Tons of brick used	217.53
Pounds ballast per cubic foot to sink	6.47

SPUR NO. 12.

The plant was swung into position on January 11, the foundation mattress sunk the next day, and the last crib was placed January 17.

Square feet in mattress	60,000
Cords of willows and poles used	626
Tons of rock used	214.13
Tons of brick used	157.49
Pounds ballast per square foot to sink	12.62

The dimensions of the cribs were:

Crib No. 1, 56 by 32 by 6 feet.
Crib No. 2, 154 by 24 by 6 feet.
Crib No. 3, 210 by 16 by 6 feet.

Cubic feet of cribs in spurs	55,088
Cords of willows and poles used	260
Tons of rock used	102.90
Tons of brick used	129.10
Pounds ballast per cubic foot to sink	7.99

BUTTRESSES.

According to the project, the only places where the buttress spurs were indicated was between Spurs 12 and 13, and 16 and 17. The river was rising and haste was necessary, if the mattresses already built for the work at Southport were to be successfully sunk. It was therefore decided to place but two of the buttresses and leave the location of the others to be determined after the completed spurs had stood the test of one high water.

Two buttress spurs were built; one 150 feet below Spur 12 and parallel to it, and the other 96 feet below Spur 16 and parallel to it. In construction they were precisely alike, and consisted of a foundation crib 120 by 28 by 7 feet, sunk at a sufficient distance from the low-water mark to permit the sinking of a top crib 100 by 16 by 6 feet, in such manner that for 60 feet it lay on top of the lower crib, and the remaining 40 feet reached to low-water mark. In the case of the two buttresses the foundation crib in each case was an old condemned barge, which was prepared by placing timbers, properly braced, on the sides and projecting 3 feet below the bottom. These timbers were intended to prevent the barge slipping down the bank. Other timbers were fastened to the inner bulkheads and allowed to project 3 feet above the deck. These were to prevent the top crib from slipping. The reason why barges were used for the foundation crib was that the two old and worthless barges were on hand and by using them the expense of building a bottom crib of willow brush was avoided.

The buttress below Spur 12 required 119 tons of ballast, of which 95 tons were required for the barge and 24 tons for the willow crib. For the buttress below Spur 16, 138 tons of ballast was required, 94 tons on the barge and 44 tons on the crib.

The last buttress was completed on January 23, and preparations for the Southport work were immediately commenced.

SOUTHPORT WORK.

In 1891-92 and 1893 bank-protection work in the Carrollton Bend, of which Southport forms a part, had been done. Changes in the line of the wharf front and a small cave at the lower end rendered further work necessary. The past season's work consisted in placing 112,500 square feet of mattress along the front and lower end of the Yazoo and Mississippi Valley Railroad wharf, between Spurs 3 and 4. The project contemplates covering the bank under the wharf with mattress work, but this could not be done on account of the high stage of the river.

On January 25 the plant was transferred from Algiers Point to Southport, and on the next day the sinking of mattresses commenced. The first mat sunk was a

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small affair, built especially to fit in at the lower end of the wharf. Its dimensions were 150 feet long on one edge, 200 feet long on the other, and 60 feet wide. The other work consisted of a strip of mattress 100 feet wide and 1,020 feet long, extending along the wharf front from 74 feet below the center line of Spur 3 to the center line of Spur 4. High stage of the river and heavy drift interfered greatly with the work, which was not completed until February 3, the actual working time being eight days.

The total cost of sinking the mattress at Southport was $2,814.77, or at the rate of $0.02502 per square foot of mattress in place.

The total field cost of the Southport work was $8,790.77, divided as follows:

Construction at Cowpen Bend	$5,242.50
Towing, Cowpen Bend to New Orleans	733.50
Ballasting and sinking into position	2,814.77
Total	8,790.77
Square feet of mattress	112,500
Cost per square foot in place	$0.07814

The work of the season was closed February 4, the force disbanded, and the plant removed to the Government depot. Mr. J. R. Allen, United States overseer, has had immediate charge of the sinking of the mattresses and cribs in New Orleans Harbor during the past season, and as will be seen from the cost of this portion of the work, has acquitted himself in a manner that would have been creditable to one of long experience. It is especially so for his first season on work of this character.

Caving banks.—During the past year caving of the bank has occurred at Southport and in the Third district reach. The first cave at Southport was a small matter, and consisted of the slipping out of the box levee built by the railroad authorities to protect their freight yard. The cave was about 50 feet long and was at the point where the box levee joined the railroad wharf on the lower end. The cave appeared to be superficial, as the bank below low-water mark did not move. The damage has since been repaired and the levee rebuilt practically on the original line.

The other cave at Southport was a much more serious one. On December 23, at 4 a. m., the wharf for a length of about 100 feet measured on the front line, by a depth of about 70 feet, slipped down into the river. Soundings in the cave gave a depth of 65 feet. By the use of extra long piles the wharf has been rebuilt. The location of the cave was on the unprotected portion of the bank, about 250 feet above the center line of Spur No. 3.

The Third district cave occurred on August 23, at 1 a. m. From a point about 100 feet below the head of France street, and extending upstream for a distance of 810 feet, the levee sunk down and slipped out. The fore shore and skeleton wharf constructed by the Orleans Levee Board was carried in for a length of 1,115 feet. It is claimed by the levee board inspector that a portion of one of the mattresses placed by the Government came to the surface near the head of Mazant street on August 4, at 3 p. m. The Orleans Levee Board have undertaken extensive work all along the Third district front, consisting practically of a continuous skeleton wharf of extra long piles, well braced and tied together, back of which is a tongued and grooved sheet-pile bulkhead, against which the levee is built. As this construction extends in many places over 100 feet out into the river it would be almost impossible to place either spur dikes or continuous revetment in this bend without removing the piling.

BALLAST.

Material for ballasting the mattresses and cribs has been obtained from various sources, as follows:

ROCK.

	Tons.
On hand last report	3,710
Ships' ballast received since	1,037
Rock purchased under contract	1,131
Furnished by Illinois Central Railroad	362
Total	6,240
Used during the season	3,210
On hand	3,030

The purchase price has varied considerably, and also the cost of unloading on the bank, but a fair average would be about $2 per ton.

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SURVEYS.

Hydrographic surveys of the various portions of the harbor where bank protection work either has been done or is contemplated are now in progress. The survey of the Third district reach has been completed and the survey of the Carrollton and Gouldsboro bends commenced.

Very respectfully, your obedient servant,

H. S. DOUGLAS, *Assistant Engineer.*

Maj. GEO. MCC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 4 F.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER, IN LOCAL CHARGE OF GOVERNMENT DEPOT, NEW ORLEANS, LA.

NEW ORLEANS, LA., *May 1, 1899.*

SIR: I have the honor to submit the following report of operations covering care, preservation, and repair of the plant belonging to the district for the period from May 1, 1898, to date:

At date of last report the plant consisted of 44 pieces. During the year 5 pieces have been disposed of, viz: The steamer *Osceola*, condemned and sold; barges 16 and 28, transferred to the Quartermaster's Department, and barges 542 and 546 condemned and used as the foundation cribs for two buttress spurs sunk as a portion of the Algiers Point bank protection.

The plant now on hand consists of 39 pieces, as follows: Standard gunwale barges Nos. 1 to 10, No. 15, and Nos. 17 to 27; ordinary gunwale barges No. 550 and B; floating warehouse, dock, pile driver No. 32, quarter boats *New Orleans*, *Alpha*, *Beta*, *Gamma*, and *Delta;* tugs *General Comstock* and *Tilda*, steamer *Ruby*, hydraulic dredge *The Ram*, small pump boat, two small lighters, besides two camel docks, side dock, pontons, skiffs, etc. A considerable portion of the plant has been kept in Giles Bend, above Natchez, where rock for bank revetment work is being received and stored on the bank. The lack of specific allotment for plant has limited the amount of repair work during the past season to what had absolutely to be done.

REPAIRS.

Barge No. 4.—Numerous graving pieces were put in the sides, the deck patched, and the sides and rakes calked; cost, $117.42.

Barge No. 10.—Numerous graving pieces on the sides, deck patched; two tie rods and eight timber heads put in; rakes patched and sides and rakes calked; cost, $208.40.

Barge No. 550.—Numerous graving pieces in the sides; deck sheathed, and sides and rakes calked; cost, $126.48.

Barge No. 542.—Two lower seams calked; cost, $8.25.

Barge No. 546.—Two lower seams calked; cost, $9.65.

The Ram.—The machinery was repaired as follows: New lower half of lignum vitæ bearing for cutter shaft. New sleeve on cutter shaft. New section of suction pipe of No. 10 steel. Two new steel plunger rods and new rock shaft for Knowles steam pump. Two thrust rings for centrifugal pump. Two new turn-buckles and four eyebolts for bow wench engine. Eight cast-iron sheaves, four steel pins, and eight pieces steel boiler plate for sheave liners were furnished; also a new set of fire door liners and grate bars. A new piece of copper steam pipe for compound engines was put in, and a new shell for the cataract pump. The repairs to hull and cabin consisted of new deck under forward wench engine and platform; foundation of compound engines and boiler beams braced; deck under boiler sheathed, and cylinder timbers of propelling engines reenforced and refastened. The spud frame was strengthened, wheel repaired, port hog-chain brace scarfed, deck patched, and two new fenders put on. The cabin was painted. Cost, $1,003.77.

Tug General Comstock.—Boiler was repaired by putting in one new flue and new leg for steam drum; cost, $180.

A small flat, 45 by 12 by 3 feet, was built of cypress, in which was installed the large wrecking pump formerly on the *Tilda*, and the boiler formerly on the condemned launch *Alaska*. This flat was intended to supply water when grading banks by the sluicing process. Cost, $316.67.

Pile driver No. 32.—The leads were lengthened and altered to suit a steam hammer. The old boiler was removed and the boiler formerly on the condemned dredge *Pah Ute* installed. Cost included in current repairs.

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New skiffs.—Twenty new skiffs were built at a total cost of $568.04.

Two new barges to replace Nos. 16 and 28, transferred to the Quartermaster's Department, are being built under contract. Slow progress on the construction has been made on account of the difficulty of obtaining suitable timber of the large dimensions required.

CURRENT REPAIRS.

These repairs are of that character that it is difficult to specify, but necessary to the maintenance of the plant. They comprise such matters as replacing rotten wooden timber heads with iron bitts, repairing doors and windows, ice boxes, the roofs of quarter boats, pile driver, etc., the reels for wire cables, calking docks, etc., skiffs, etc. The cost has been about $2,000.

CARE OF PLANT.

This includes supervision at the depot, watchman, cleaning out holds of barges, quarter boats, etc., painting same, cleaning and painting wire cables, putting out lines and shifting spars to hold fleet as the river rises and falls, labor incidental to handling sacks for levee purposes, and other incidentals. The cost for the past year has been $5,654.86.

CONDITION OF PLANT.

There is no way of determining with exactness the condition of the plant. It is serviceable, but it is fair to assume that it has deteriorated at least 10 per cent in the past year, and that extensive repairs will shortly be required to keep the quarter boats and barges in serviceable condition. The tug *Comstock* is now in dock and is found to require almost a new hull. Four barges that were serviceable last year are now beyond economical repair and will have to be replaced with new ones. The hulls of the quarter boats *Gamma* and *Delta* are rotten and will have to be rebuilt. It is probable that a number of the barges will require extensive repairs to keep them in serviceable condition, and that almost the entire floating plant will have to be recalked.

It is reasonably certain that the plant will be largely increased in the immediate future, and the necessity of a large dock or ways on which the large pieces can be raised out of the water for repair of such portions as are constantly submerged is becoming evident.

Very respectfully, your obedient servant,

H. S. DOUGLAS, *Assistant Engineer.*

Maj. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 4 G.

REPORT OF MR. A. F. WOOLLEY, JR., ASSISTANT ENGINEER, IN LOCAL CHARGE OF IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

NEW ORLEANS, LA., *May 1, 1899.*

SIR: I have the honor to submit the following report upon the work of improving the Atchafalaya and Red rivers, Louisiana, for the period from May 1, 1898, to May 1, 1899.

DREDGING OLD RIVER.

The general condition of Old River, in so far as it relates to the amount of dredging necessary, was much the same as during the low-water period of the previous season.

The greater part of the season's work was confined to dredging and maintaining a navigable channel across the bar at the mouth, the remainder being covered by the reach between Dead Tree and Ash Cabin. The bar at the mouth was composed approximately of 70 per cent sand, 5 per cent gravel, and 25 per cent clay.

The class of material encountered in the reach between Dead Tree and Ash Cabin was approximately 35 per cent clay and 65 per cent sand. The dredging in the vicinity of Dead Tree and Ash Cabin was made necessary by the soft mud and clay sides of the channel sloughing or sliding into the channel. The channel being thus partially filled up or restricted in width with soft mud or clay, which does not scour during the lower stages of water, causes a further deterioration of the low-water channel from a deposit of sand both above and below these restricted points.

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As explained at some length in my last annual report, this sloughing of the banks at low water is obviated, in so far as it is practical or economical, by thoroughly draining all lakes in the basin of the Old River bed.

The dredge *Ram* left New Orleans August 7 and arrived at Old River on August 11. Dredging was commenced on August 15 and discontinued on August 22, owing to temporary rise in the river. Dredging was resumed on September 5, continued to October 31, again suspended to November 7, and again suspended on November 9. No further work was necessary after the latter date and the dredge was taken to New Orleans on November 17, to be laid up for the season.

The following statement will show the details of the work for the period of actual operations, together with other data that may be of interest:

Number of days (of ten hours) of actual dredging	43.5
Number of days (of ten hours) delayed by breakdown, minor repairs, shifting the location of dredge, moving anchors, and raising lines for passing boats	14.5
Number of days when work was suspended owing to temporary rises in the river and other causes	28
Sundays (no work)	12
Total number of days that the dredge was in the field (including eight days' journey from New Orleans to Old River and return at beginning and end of season)	104
Average number of cubic yards handled per day (not including delays incident to a working-day of ten hours)	1,700
Average number of cubic yards handled per working-day (of ten hours)	1,270
Cost per cubic yard for material handled during season, for period of dredging operations (including all expenses of the dredge for time in the field)	$0.062

Number of cubic yards handled at the localities where dredging was required, and average handled per dredging hour for each.

Location.	Class of material.	Average handled per hour.	Total.	Cost.
		Cu. yards.	*Cu. yards.*	
Carrs Point	70 per cent sand, 5 per cent gravel, and 25 per cent clay and mud.	170	43,000	$2,666.00
Dead Tree to Ash Cabin.	65 per cent sand and 35 per cent clay and soft mud.	160	30,800	1,909.00
Total			73,800	

Attention is called to the fact that the cost per cubic yard for material handled during the season is in excess of other years. This increased cost was due to the forced idleness of the dredge for twenty-eight days, owing to temporary rises in the river and other causes, during which time the crew could not be sent away or let go on account of the quarantine regulations.

CARE AND REPAIR OF PLANT.

The hull of the *Ram* is in bad condition and repairs of only a temporary nature were made, as it is intended to be replaced with a new hull.

During the month of December specifications were prepared for a new steel hull for the dredge *Ram*. The contract was entered into February 27, 1899, with the Springfield Boiler Works, of Springfield, Ill., for furnishing a steel hull, 125 feet long, 30 feet beam, and 7.5 feet depth of hold, together with steel cutter frame and spud frame, for the sum of $14,600, to be delivered on August 1, 1899. The progress made by the contractors to date has been very unsatisfactory.

CARE OF EXISTING WORKS—ATCHAFALAYA SILL DAMS.

During the month of December, 1898, surveys were made in the vicinity of these structures to determine their condition. The dams themselves were found to be in fair condition, but the conditions in their immediate vicinity were much the same as those prevailing immediately after the high water of 1894. On March 5, 1899, I submitted a special report on these dams to Capt. Henry Jervey, which I insert here, as it is based on the information gathered from the very latest survey at hand:

"The construction of these dams was commenced in 1887 and completed in 1889. The structures consisted of alternate layers of willow mattresses, stiff clay, and gravel or stone.

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"Gravel was used in sinking a number of these mattresses where no strong current prevailed.

"The original project contemplated six of these sill dams; two of these (Nos. 1 and 3) were constructed. Both of these structures are still in place, are in fair condition, and have had practically no repairs since their construction; the total cost for maintenance being only a few hundred dollars.

"The crests of these dams have settled very materially since their construction. The sill or floor mattress of both structures have remained generally unchanged in elevation during the past five years. The shore portion of these structures consists of a willow mattress, or the sill proper, extended from low-water shore line to the top of the bank on either side of the river. This shore portion of the sills, which is alternately wet and dry, is very badly decayed where not covered by silt. This decay is of no great importance as the slope is very regular, thoroughly paved with stone, and has satisfactorily resisted the action of the strong current passing over them.

"I have annually made careful surveys of these dams and in their immediate vicinity for the past five years. In taking soundings over the dams themselves it is extremely tedious to get results that will permit of a thoroughly satisfactory comparison one year with another. This difficulty is due to the very rugged surface of the structure itself.

"I believe I have devised means by which the error of observation in taking soundings has been reduced to a minimum. The shore ends of the crests of the dams, which are exposed to plain view during low water, show very plainly that the error of observation in taking soundings over them might easily be from 1 to 4 feet, all due to the irregular surface of the structure. The crests of these dams have settled since their completion from 1 to as much as 12 feet. This settlement of the crest is, in my opinion, due principally if not entirely to a compression of the structure itself and to the slight general settlement of the entire structure in finding a firm bearing very soon after its completion. After the settlement due to the latter cause, I am of the opinion that the changes during any one year are of less extent than the errors of observation between any two successive surveys.

"If this be true, very marked changes may not be looked for by a comparison for a short period, and I have always held this point in mind in the consideration of this subject.

"The crest of Dam No. 3 has settled approximately twice as much as Dam No. 1. The reason I advance for this is its somewhat greater original height and a more extensive use of clay and gravel than in Dam No. 1.

"These dams were built before my connection with this particular work, and there is no very clear record of clay having been used at all in Dam No. 1.

"By a comparison of contours, from soundings of December, 1894, and December, 1896, it will be noted that contour of 1896 shows a decided silting in the channel above the dams, between the dams and below the dams. The greatest silting in the vicinity of dams, and below Dam No. 3, amounts to 20 feet. This silting in the bed of the channel I attribute to the long period in the preceding season, during which there was a medium stage of water in the Red, resulting in a very strong flow through Old River toward the Atchafalaya, and of course carrying a large percentage of silt.

"The volume of water turned into the Atchafalaya by the Red and by Old River from the Mississippi was only sufficient to produce a very gentle current in the larger area section of the Atchafalaya, thereby depositing much silt in the Upper Atchafalaya.

"A very marked demonstration of this assertion is to be had from the fact that it was necessary, during the month of October, 1896, to dredge a channel across a bar in the Atchafalaya near its head, where a depth of 40 feet or more had been known to prevail for a number of years past.

"At the time I considered this apparently favorable silting as only a temporary condition, which would be removed by the next stage of water, giving a stronger current in the Atchafalaya. A survey after the next high water (1897) showed that all trace of this abnormal deposit had been removed, and generally a slighter greater depth in the vicinity of the dams than had prevailed previous to this heavy silting.

"I mention this point much in detail to bring out the facts that peculiar local conditions, which at times seem to conspire to the presentation of signs that are on their face favorable, but are of reality of no moment, and would, if not fully considered, give a false sense of security. I have always endeavored to repeat these surveys at a time when these misleading conditions were absent, and have done so in so far as other duties would permit.

"During the past season (1898) the conditions have been somewhat similar to those of 1896, and the present depths of water in the immediate vicinity of the dams does not, by some several feet, represent that which exists during or immediately after an extreme flood. A recent deposit of sand could be distinctly felt with the lead during the latest survey.

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"These sill dams have to my mind fulfilled every one of the objects for which they were placed, and with a minimum cost for repairs. When I say fulfilled every object I will enumerate: The cross section over the crests of dams has remained unchanged, with the exception of the small percentage of increase, due to a compression of the dam itself, thereby fixing the outlet capacity of the Atchafalaya. The former violent caving of the banks of the Atchafalaya has ceased. The cross section of the Atchafalaya, in the vicinity of the dams, has increased only in so far as such increase was necessary to carry increased flood heights. The river channel has regulated itself, since the discharge has been limited by the dams. This regulation has manifested itself to a marked degree in the cutting off of the sharp and irregular points left by the former rapid caving, the violent eddies (caused by the tortuous and irregular channel) have become less numerous, less extensive, and of less force.

"The depths of the channel, from the head of the Atchafalaya to a point several miles below the dams, has remained practically unchanged, with the exception of the deep points immediately below each of the dams, as before mentioned.

"These greater depths below each of the dams is due to the tumbling action of the currents passing over the dams.

"These deep holes below each of the dams have caused considerable caving on the right bank below Dam No. 3, and has since the completion of these dams necessitated the moving back of the levee at that point.

"The deep hole below Dam No. 1 is less pronounced than the former, but has been sufficient to cause the right bank, between the dams, to settle generally from 1 to 5 feet, and extending irregularly from shore line to points 80 to 100 feet above shore line at low water. This settlement of the right bank did immediately after the high water of 1897 affect the shore portion of sills of both dams near and above the low-water line on the right bank.

"As a remedy for this trouble I would recommend that the sill or floor mattress be extended on the lower side of the dams to a point that will reach deep water, thereby preventing greater depth at these points, which have a known tendency to scour.

"This extension of the sill or apron to be composed of two mattresses, 150 by 400 feet each, to be placed in the channel, adjoining each other, extending up and down stream, the upper ends abutting the original sill or floor mattress.

"One shore mattress to be 150 by 120 to 170 feet.

"One shore mattress to be 150 by 130 to 140 feet.

"These two latter will be of irregular shape and are to fill the space between the two channel mattresses and the shore line.

"This will give a total of 162,000 square feet of mattress, at 7 cents in place, equal to $11,340.

"For Dam No. 1 I would recommend a similar treatment, to be composed of two mattresses, 150 by 300 feet each; one mattress 150 by 250 feet; one mattress 150 by 170 feet, or a total of 153,000 square feet, at 7 cents in place, equal to $10,710.

"Thus the total for the two dams would be $22,050, plus, say, $2,500 for contingencies, making a grand total of $24,551.

"There is less urgency in the matter of Dam No. 1 than in that of No. 3, and should the plant be more urgently needed elsewhere during the coming season, the work below Dam No. 1 might safely stand over until the following season.

"As to the advisability of another dam I can not at present see the need.

"If an additional dam were built it would have to be about 1 mile below Dam No. 3 in 35 feet of water; should have the sill extended some distance below, as I propose for Dams Nos. 1 and 3, and would be more expensive than the protection which I propose for the latter."

SURVEYS, GAUGES, AND OBSERVATIONS.

NEW ORLEANS HARBOR.

During the month of August, 1898, I made a survey of Algiers Point. During the months of September–October, 1898, I was engaged on a survey of the Third district reach of New Orleans Harbor, between the Northeastern Railroad wharf and Egania street. This survey was suspended from October, 1898, to March, 1899, owing to the necessity for more urgent work elsewhere. In March, 1899, this survey was resumed and completed in the month of April.

During April and May, 1899, a survey was made of Southport and the vicinity to such an extent as the existing high stage of the river would permit.

Survey of Gouldsboro Bend, above Algiers Point, is now in progress, but is being much hampered by the high stage of the river.

OLD RIVER.

By resolution of the Mississippi River Commission a survey was made of Old River. This was commenced in December, 1898, and completed in March, 1899,

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having been seriously retarded by bad weather and a rising stage of the river. This survey is very complete and will show sections not over 300 feet apart. All of the maps and cross sections have not yet been completed. A number of the cross sections have been compared with those of 1894–95 and show a general increase of area below the 35-foot plane. The increased area is had by an increase in depth and a decrease in width of section, the greater part of this increase having been within the past three years.

The action of the water entering Old River from the Mississippi has caused a recession of the bank at the mouth of Old River. The maximum of this recession is 900 feet since 1895, the greater portion having occurred since 1896.

It is a fact worthy of note that during the past few years the period has been prolonged during which there is a strong current through Old River from the Mississippi to the Atchafalaya, at or near the flood height.

The practical effect of this prolongation of the period during which Old River is subjected to this scouring action has been the general increase of the Old River section below the 35-foot stage. In time and with several successive years presenting this favorable condition to scouring, it is possible that Old River might enlarge to such an extent as to become a source of anxiety. The high-water width of Old River is practically equal to that of the Mississippi and can discharge more water than the Atchafalaya, but the wide high banks are annually being built higher by deposit. When these banks have been built to such an height as to restrict its high-water area to something near that of the Atchafalaya then the present channel of Old River will be rapidly enlarged.

I am therefore of the opinion that the ultimate serious enlargement of Old River will not be within several years. There is no advantage in allowing the present channel of Old River to become greatly enlarged in excess of the requirements of low-water navigation. This should be prevented at the proper time by a sill.

The recession of the right bank for a distance above and below the mouth of Old River has been very marked during the past two years.

MISCELLANEOUS.

On April 1 I went to Dubuque, Iowa, to inspect the new towboat *Gen. John Newton*, which had been reported ready for delivery. I found the boat still incomplete in a number of details, besides being completely icebound. On April 11 the boat left Dubuque for New Orleans, a number of small matters having been placed in satisfactory condition after my arrival in Dubuque, the other details to be made satisfactory on the trip down the river or upon arrivol at New Orleans.

Much delay was experienced on the way down, owing to blocks of wood, small steel chips, and scale being left inside of cylinders and other parts of the machinery, and to trouble with inadequate or uncertain feed to the circulating pumps. The boat arrived at New Orleans on April 24.

The first speed trial was made on May 4, when the boat developed an average speed of 13.3 miles per hour downstream and back. Pursuant to your instructions, I have been employed during the latter part of May in making certain experiments to solve the problem of finding a substitute for rock, to be used in sinking mattresses for bank-protection work on the river. My experience leads me to believe that a substitute can be had in the shape of a concrete, made of river sand and gravel, for about 60 cents per ton less than the prices you have been paying for rock.

My experiments have just about been completed and I am not in a position to give details at this time.

Very respectfully, your obedient servant,

A. F. WOOLLEY, Jr.,
Assistant Engineer.

Maj. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 4 H.

REPORT OF MR. W. J. HARDEE, ASSISTANT ENGINEER, IN LOCAL CHARGE OF THE LOWER TENSAS, ATCHAFALAYA, LAFOURCHE, BARATARIA, PONTCHARTRAIN, AND LAKE BORGNE LEVEE DISTRICTS.

NEW ORLEANS, LA., *May 1, 1899.*

SIR: I have the honor to submit the following report on levee work in the Lower Tensas, Atchafalaya, Lafourche, Pontchartrain, Barataria, and Lake Borgne Levee districts, for the period extending from May 1, 1898, to April 30, 1899.

GENERAL METHODS.

1. Construction.—As soon as the high water of 1898 had subsided work was promptly resumed at all levees where operations had been suspended.

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The first of the levee work to be done under the 1899 allotments was placed under contract about the middle of June; the balance was put under contract from time to time thereafter until the available money was all placed.

During the latter part of September yellow fever made its appearance in New Orleans and several neighboring towns. Quarantines were immediately established and maintained from six weeks to two months, depending on the locality. The lines, however, were not so tightly drawn as during the preceding year, when yellow fever prevailed, yet the existence of quarantine materially affected progress of levee work, both as to levees constructing and the commencement of contracts which had just been awarded. During the first seven months of the year frequent and heavy rains were experienced, in fact the weather was unprecedentedly unfavorable for levee building, and to this cause must be charged the very small amount of work done during the past year, as compared with previous years, and the large number of delinquent contracts.

During the month of March the river commenced to rise rapidly and shortly overflowed its banks, causing a general suspension of levee work; at the date of this report the foreshores are still submerged, and it has not been possible to resume operations. A large amount of work remains to be done to finish existing contracts.

Tabulated statements for each district are herewith submitted, furnishing detailed information for completed levees, partially completed levees, and levees under contract but not yet commenced.

2. Comparative condition.—Since the flood of 1897 the levee line of the several districts has been vastly improved, both as to grade and cross section, by the expenditure of large sums of money on the part of the United States, the State of Louisiana, and the local levee boards. The tabulated statement below will show, with reference to the flood plane of 1897, what the condition of the levee line of each district will be when existing contracts shall have been completed. It is believed that the funds which the several authorities propose to expend during the fiscal year ending June 30, 1900, will eliminate all the extreme low lengths noted in the statement, except in the Lower Tensas district; in that district caving bank has rendered the construction of several large new levees necessary, and those new levees will about exhaust the available funds and leave little money, if any, to be applied to the enlargement of existing low lines.

Condition of the levee line of each district when existing contracts shall have been completed.

Height above 1897 water.	Levee districts.					
	Lower Tensas.	Atchafalaya.	Lafourche.	Pontchartrain.	Barataria.	Lake Borgne.
	Miles.	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Less than 1 foot	13	7.29	.....	21.50	8.60	1
From 1 to 2 feet	22.50	18.19	9.30	50	23.09	15
From 2 to 3 feet	20	25.58	21.76	29	24.65	15
More that 3 feet	70.61	77.12	51	25.16	14.05	16.98
Total	126.11	128.18	82.06	125.66	70.39	47.98

The United States Lake Borgne Levee district extends from New Orleans to the Gulf of Mexico. Below Bohemia (1015 L.) there is nothing like a definite levee system, and the United States has confined the expenditure of levee allotments to the State Lake Borgne Levee district.

3. Construction by dredge.—An important departure in levee building, bearing largely on the future cost of work, has been made during the past year by the employment of steam dredges, instead of the customary means, to do the work. Many mistakes were made in the management of the dredges and the handling of the work, but the errors were gradually eliminated, and at this writing two of the machines are working at a profit. A large amount of the unprofitable work done was due to the inexperience of the contractors and to the fact that the dredges were not suitable to the task in every particular. From the experience gained I am confident that a machine, built upon modified lines to meet the usual conditions surrounding levee work, is entirely practicable; that such machines can be built at moderate cost and can be operated successfully, and that they will reduce the cost of levee work at least one-half. Much confidence is entertained on this point, because what is termed "bad work" (work which is least favorable for construction by customary means—wheelbarrows or teams) can be most profitably done by dredge, the local conditions being favorable for machine work. It does not appear certain that a machine is just now in sight which can universally compete with teams, but further experience and time will most probably develop one that can. The contemplated machine, however, is estimated to be capable of successfully competing for and commanding 75 per cent or more of the levee work annually done. Three dredges in all have been employed;

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their experience will be found in detail in the report of the district where each was engaged. Several dredges have been employed during the year on State levee work, and their experience has also been considered in estimating the practicability of a successful levee machine.

4. Muck or base ditches.—The practice of cutting a muck or base ditch has been continued at places where the existing embankment was known to be leaky. Leaks are usually due to holes or cavities made through or under the embankment by burrowing animals or partly decayed logs or other vegetation not removed from the surface of the ground, or just beneath it, or surreptitiously introduced into the body of the levee at the time of its construction.

5. Repairs.—During the summer and early fall months the levee lines were repaired and put in good condition. Repairs consisted of cutting and removing weeds or other objectionable vegetation and drift logs, restoring rain and wave wash, resodding where grass had failed to grow, and draining borrow pits.

6. Supervision.—I was commissioned captain, Third U. S. Volunteer Engineers, and served from August 1, 1898, to January 2, 1899. During my absence Maj. William Starling occupied my position as assistant engineer, exercising general supervision of all the United States levee work in the several levee districts in the fourth district, improving Mississippi River. After my return, and until he retired on April 10, Major Starling had general supervision of the Lower Tensas district only.

Mr. L. E. Lion has had local charge of the Lower Tensas district; Mr. W. E. Knobloch has had local charge of the Atchafalaya district; Mr. J. W. Monget has had local charge of the Lafourche and Pontchartrain districts; Mr. John Klorer has had local charge of the Barataria and Lake Borgne districts.

These men represent this office in the management of protection work during high water. Throughout the year they see that the levee line is kept in thorough repair, draining borrow pits and replacing wave wash after each high water, and keeping weeds cut down at all seasons; they make all surveys necessary for proposed work; they supervise the work of contractors and inspectors; do all instrumental work necessary to the proper execution of contracts, and certify to their satisfactory completion; they make recommendations as to the efficiency of the levee line of their district which intimate contact with it brings to mind; they are required to carefully inspect every foot of their line once a month, and oftener if practicable. In addition to such special reports as circumstances from time to time demand, they are required to submit monthly reports specifying the extent and dates of their inspections, what surveys or special examinations have been made, the general condition of the levee line, character and progress of repair work, the date of commencement and completion of contracts under way, and the percentage of embankment in place at each.

An inspector was stationed at each levee during its construction. It was his duty to be present during working hours, see that the specifications were complied with, keep a daily record of force and operations, and submit weekly reports of same. The inspectors were paid $75 and $90 per month.

7. Preservation of works.—Nothing further than was stated in my last annual report has been done toward constructing warehouses for storage of high-water protection materials at intervals of 5 miles on the levee line, under your project of July 9, 1897, approved July 21, 1897. It is proposed, however, to promptly proceed with this work; to complete, if possible, at least all of the earthen foundations by next spring, and thereby establish distributing points for high water protection materials, and obviate the necessity for barge service, as practiced in the past.

8. High-water protection.—During April the river reached a stage of 47.3 feet at Vicksburg, 43.3 feet at Red River Landing, 36.7 feet at Bayou Sara, 23 feet at College Point, 16 feet at Carrolton, and 7 feet at Fort Jackson. A few years ago, on account of the inferior condition of the levee line at that time, the stage reached would have constituted quite a good-sized flood, and of sufficient proportions to render considerable protection work necessary, but owing to the present vastly improved condition of the levee line no protection work has been necessary this spring.

About April 1 the condition of the upper river was favorable for an extreme flood, but fortunately none materialized. As the river was still rising at Cairo, and its ultimate height uncertain, precautionary steps were taken in the Lower Tensas district against accident to the levee line, against which there was considerable water.

The district was divided into four beats, and each beat daily patrolled by an inspector, for the purpose of keeping the line under close observation. These men were recalled about April 20, when it was seen that no need for further apprehension existed.

LOWER TENSAS DISTRICT.

Work was continued on new L'Argent Levee (664 R.), and it was entirely completed in November.

Work was resumed at Delhi (680 R.), Rifle Point (689 R.), Esperanza (715 R.), and Ashley to Fairview (725 R.) levees as soon as the stage of water in the river permitted. Delhi and Esperanza levees were completed in August.

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After completing one of the two remaining sections of Rifle Point Levee the contractors moved their force from the work, and after repeated ineffectual efforts to have them resume work the contract was annulled. The contractor for Ashley to Fairview levee had only a small force at work and did not succeed in completing his contract by January 21, when the river overtopped its banks and forced him to suspend work.

Under the 1899 allotment contracts were made for the enlargement of the levee at the following localities, aggregating 56,272 linear feet and embracing 445,911 cubic yards of earthwork:

Panola (646 R.), Duckpond (648 R.), Stockbridge (660 R.), Waterproof (663 R.), Aquasco (679 R.), Esperanza (711 R.), and for building a new levee at Ashley (724 R.) 13,346 linear feet long and containing 224,400 cubic yards of earthwork.

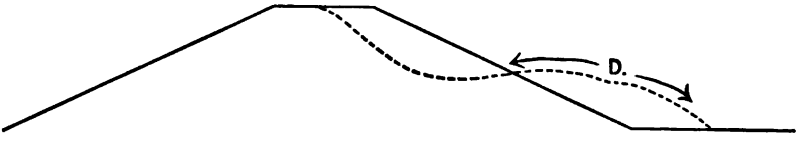
During August an unusual rate of caving took place at Kempe (657 R.) and soon breached the existing levee. A line of new levee, 3,147 linear feet long and embracing 150,000 cubic yards of earthwork, was staked out, advertised, and awarded to Helgason Brothers, who promptly commenced work. Quarantines at first, and later on bad weather, retarded progress, so that the levee instead of being completed by contract date, December 31, 1898, was not finished until March, 21, 1899. In the meantime the abnormal caving of bank continued and threatened to destroy the old levee at the point where it was proposed to join on with the lower end of the new line. An extension 1,982 feet long, to contain 85,000 cubic yards of earthwork, was staked out and advertised. Only one proposal was received, which was considered excessively high, and it was rejected. The season was so far advanced that it was deemed inadvisable to lose any more time in advertising. An unsuccessful attempt was made to secure the necessary force by open market agreement at 25 cents per cubic yard.

All the teams which could be secured, numbering 178, were secured and employed at a per diem rate. In addition, a day force of about 150 wheelbarrows, supplemented by 200 convicts with wheelbarrows, was employed. The ground upon which the levee was building was low, with but very poor natural drainage. The river soon reached a stage which prevented draining the borrow pits into it; artificial drainage had to be effected, and a pumping station was established. The weather throughout January and February was unprecedentedly bad; one rain alone amounted to 6¼ inches (reported by Vicksburg station of the Weather Bureau), and flooded the borrow pits and space between the protection levees so deep as to entirely submerge the pump, which had to be raised at considerable expense and loss of time. In the meantime the rising river made it necessary to push the work, and to keep the forces employed earth was moved from 600 to 1,000 feet. The levee sloughed and sunk at a number of places, amounting in all to a length of about 1,000 feet.

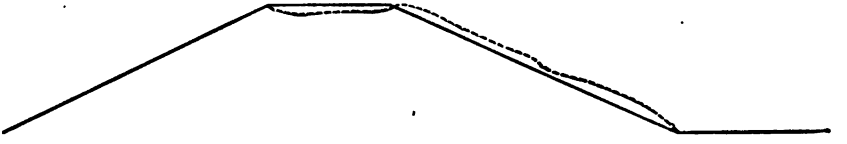
When the river reached a stage which drove the working forces from the river to the land side of the levee, all of the line, except the sloughing lengths, was practically completed. The sloughing lengths were several times brought to the required cross section, but could not be maintained. They were easily kept well above the river surface. Work was continued on them until April 19, about which time the river came to a stand; as all danger was then over, and as the work being done was very costly, all work was discontinued.

The following remarks, relative to the sloughing and sinking at Kempe, are quoted from a report by Mr. Lion:

"Immediately after the heavy rain (6¼ inches above referred to), the embankment began to show signs of sinking and sloughing. The embankment would first bulge out or swell on the slope, as shown by the dotted lines in the following diagram:



"In a few days half of the crown would break off and part of the slope would slip outside of the base, assuming the shape shown in the following diagram by the dotted lines:



"As the material was replaced in the sloughs the portion of the self-made slope marked D would rise. In one instance this process of sinking at the crown and rising on the slope continued until the portion D was within 3.5 feet of net grade.

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"An insecure foundation is undoubtedly the cause of this sinking, for the material used in building the stations which have sunk did not differ from that used in other portions of the line. The rising of a portion of the embankment as the crown subsided lends weight to this theory. The weight of the embankment pressed the foundation down, and the foundation being in a plastic condition was thus forced up elsewhere, raising a part of the slope with it until equilibrium was established. Whenever this equilibrium was disturbed by placing more material in the depression, the material on the slope rose proportionately. Borings show that layers of blue clay and sand underlie the upper strata of buckshot."

Construction of a new levee by the local levee board at Claggett (644 R.), occasioned the abandonment of 2,101 linear feet of embankment, containing, approximately, 19,917 cubic yards of earthwork; a new levee was built by the United States at L'Argent, which occasioned the abandonment of 11,004 linear feet of embankment, containing, approximately, 103,437 cubic yards of earthwork.

Of the 665,851 linear feet, or 126.11 miles, of effective levee on April 30, 1899, there are 485,145 linear feet, or 91.88 miles, built wholly or in part and paid for by the United States.

The Mississippi River Commission included Davis Island, Mississippi, in the Lower Tensas district, and allotted $3,000 to be expended on the levee line of the island. A complete instrumental survey was made during February for the purpose of determining the exact condition of the existing line and to secure information to guide the most advisable expenditure of this as well as future allotments.

A provisional grade, equal to 52 feet on the Vicksburg gauge was adopted, and a contract made for the enlargement of 10,310 linear feet of levee, to contain 22,383 cubic yards of earthwork. At the date of this report the work is 97.5 per cent completed; operations were suspended on March 31, on account of high water, and have not yet been resumed.

The local levee board, styled "Palmyra Levee Board," is doing an equal amount of work.

ATCHAFALAYA LEVEE DISTRICT.

As soon as the stage of the river permitted, work was resumed at Raccourci to Longwood (785 R.), Fleta (786 R.), New Texas (786 R.), Poche to Morganza (787 R.), Morrison (797 R.), Point Coupee (798 R.), St. Claude (805 R.), Nina (806 R.), Highland (815 R.), Belle Vale (826 R.), Viola (828 R.), and sections 427 to 430 (870 R.); work was started in June, and all of the work, except Nina, was completed by December 15.

During September contracts were made under the 1899 allotment for 741 linear feet of new levee at Antonio (836 R.), embracing 14,203.01 cubic yards of earthwork, and for 19,427 linear feet of enlargement, embracing 169,312.09 cubic yards of earthwork, at Beaulieu to Antonio (836 R.), Missouri (840 R.), and Australia (846 R.).

Quarantine prevented the commencement of these works on contract time; about thirty days' time was lost, and at this date none of the contracts are completed, work having been interrupted by high stage of river during March and April.

A base ditch, 10 feet wide at top, 5 feet wide at bottom, 6 feet deep, and 200 feet long, was dug at Nina (806 R.) levee; a similar ditch, of same top and bottom dimensions, 5 feet deep and 100 feet long, was dug at Beaulieu to Antonio (836 R.) levee; these ditches were cut just at the river toe of the slope of the old embankment.

Wave-wash was restored and the embankment resodded from Stations 2271 to 2373, and the holes at the toe of the slope of the levee were filled at Stations 3044 and 3109, by a day force under the direction of one of our inspectors, all at a cost of $2,977.74. Informal contracts were made for removing logs, weeds, and other coarse vegetation from the levee, from Station 0 to Station 3262. The line was divided into sections of about 5 miles in length, and an informal contract made for each section. Mr. Knobloch reports that, in his opinion, this method of doing the work is twice as costly as the method previously practiced of doing the work by day force.

Caving bank rendered a new levee necessary late in the season at Robertson (854 R.); the new line is 1,186 linear feet long and contains 36,732.70 cubic yards of earthwork, and was built by the United States; it was advertised in December, commenced January 9, and completed April 12.

To provide for a threatened breach of the existing line, the district levee board built a new levee at Rose Hill (816 R.) 4,160 linear feet long, and containing 163,209 cubic yards of earthwork, and a new levee at Allendale (825 R.), 2,950 linear feet long, and containing 140,000 yards of earthwork.

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Construction of the new levees above mentioned caused the abandonment of old levee at each locality as follows:

	Linear feet.	Cubic yards of earth-work.
Rose Hill	2,986	74,000
Allendale	3,024	89,000
Antonio	600	8,900
Robertson	1,560	38,600
Total	8,110	210,500

Of the 676,784 linear feet, or 128.18 miles, of effective levee on April 30, 1899, there are 452,286 linear feet, or 85.66 miles, built wholly or in part and paid for by the United States.

To induce the introduction of mechanical devices for levee construction, a very informal contract was made with the Dilworth-Scudder Dredging Company to enlarge Section 14 of Barroza levee for 14 cents per cubic yard. Barroza is not only a very large levee, but the available building material is bad and the drainage poor, making unfavorable and undesirable work for contractors employing the usual building forces of teams or wheelbarrows. The line was divided into fourteen sections and advertised twice, and the lowest bid received for Section 14, at the first opening of bids, was 24 cents per cubic yard, and 24.45 cents per cubic yard at the second opening of bids.

The standard cross section in use is 8-foot crown, with side slopes of 3 on 1. As there was some doubt as to whether the wet material could be made to stand on a 3 to 1 slope, the contract provided that 7 cents per cubic yard would be paid for all material placed in excess of that slope up to the limit of a 4 to 1 slope. The contract also gave to the dredging company an option to build the remaining thirteen sections on the same terms, if by July 15 they had demonstrated the capacity of the dredge to do the work.

The dredge commenced work on Section 14 June 10, at which time the river was out of its banks at that point and covered the berme to a sufficient depth to float the dredge.

The dredge is 80 feet long, 40 feet wide, and draws about 30 inches; it is fitted with first-class machinery; the boom is 65 feet long, and has a fixed base on a rotary table, which swings around a full circle. A 2-cubic yard Hayard bucket is used.

The work is river side enlargement, and the average base width of the levee when completed is 82 feet; the maximum reach of the dredge is only 45 feet. It is, therefore, manifest that at least one-half or more of the material must be handled twice. Instead of putting up a conveyor at once the contractors thought, as the stage of water was favorable, they would dig into the proposed base and place the material to the extreme land part of the cross section, and then move the dredge further toward the river, fill up the excavation and build it on up to the required cross-section lines. This proved a serious and expensive error. Only a very limited amount of material was thus pyramided on the side of the levee when it commenced to slough and slid back into the pit; nor could the dredge, on account of sloughing, even succ ed in refilling the pit cut in the proposed base to its original dimensions.

Section 14 is only 735 feet long, and the dredge worked backward and forward over the section a number of times, making ineffectual efforts to get the material to stand. Our inspector at the levee expresses the opinion that from three to four times the cubic yards originally designed for section 14 were handled in this manner, resulting in a net placement of only about 25 per cent.

The contractors then applied for an extension of the limit of their original absolute contract, which was granted, and notes were furnished them for sections 13, 12, and a small part of 11, aggregating 2,872 linear feet.

A conveyor was built and put in position. The method of work consisted of the dredge working altogether outside of the final cross section and pyramiding material from one end of the line to the other as high on the slope of the old levee as it would stand without sloughing. On the second trip over the line the pyramided material had dried out, and it was picked up by the dredge and moved on the conveyor to the farther side of the cross section as required. The pyramid cut away was again built up, allowed to dry out, and then moved landward by the conveyor. This system was repeated until all the material required beyond the reach of the boom was in place. Then the dredge proceeded to put in the remaining lower part of the cross section by direct delivery.

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The conveyor was a heavy wooden truss structure, clumsily put together, on which a self-tripping car traveled, worked by wire cable from the dredge. The far end of the conveyor traveled on an iron rail track; the end nearest the dredge rested on the soft material and was picked up bodily by the bucket of the dredge and moved 5 feet or more at a time, as was required. The soft material would not permit the use of a portable track for this end of the conveyor to travel upon. Owing to the unstable base of the conveyor in the soft material, it frequently tipped over and suffered injury; much time was lost, not only in righting the conveyor when it had turned over, but in making repairs to it to cover the damage incidentally sustained. In the meantime the dredge was idle.

A light steel truss conveyor, with one end resting on a track on the levee and the other resting on a barge or the dredge boat itself, in lieu of the one used, would have been an immense improvement and saved much time and money.

The contractors provided themselves with a small pump, to be used in pumping water from the river into the pit, to keep the dredge afloat when the river was within its banks, but it never became necessary to do any pumping. When the river receded last June a large amount of water was left between the base of the levee and the comparatively higher edge of river bank; this supply was supplemented by rainfall throughout the year and proved adequate to keep the dredge afloat.

At this writing sections 11, 12, and 13 have been satisfactorily completed; the bulk of material is in place on section 14, but some trouble is being experienced in getting the extreme lower part of the slope in place on account of sloughing, due to the large amount of water (the river is well out of its banks) against the levee.

In spite of the fact that the dredge has been at Barroza for nearly a year, the low price received for the work, and the many expensive errors that were made, and the loss of time from breakdowns which occurred, it is believed that the contractors have lost no cash; they have about broken even on money, but are out their time, wear and tear on plant, and interest on money invested.

LAFOURCHE LEVEE DISTRICT.

As soon as the stage of the river permitted, work was resumed at Waguespack (906 R.) levee, and it was shortly afterwards completed. Carey Brothers had a small force to do the large amount of work under contract to them, and as a result they have finished but a small part of section 1 of Alliance (920 R.) levee, and have done nothing at all at Jamestown (898 R.), Bay Tree (906 R.), and Willow Grove (916 R.).

During October contracts were made under the 1899 allotment for the enlargement of 34,622 linear feet of levee, embracing 223,981.74 cubic yards of earthwork at Hymelia to Killona (930 R.), Pelican to Flagtown (936 R.), Lonestar (942 R.), Louisa (943 R.), and Coopersville (944 R.).

Hymelia to Killona and Lonestar have not been commenced. They were awarded to the same contractor who has Pelican to Flagtown, and he has had his entire force employed there.

Louisa and Coopersville levees are well advanced. Work was interrupted by high water in January, and the river has not receded sufficiently to permit a resumption of work.

The United States expended no money for repairs in this district. All work of that character was done by the local levee board.

A new levee 2,575 feet long and containing 75,131 cubic yards of earthwork was built by the local levee board at Ashton (839 R.), to provide for a threatened breach of the old levee. This new levee occasioned the abandonment of 2,616 linear feet of old levee, containing 75,131 cubic yards.

Of the 433,237 linear feet, or 82.06 miles, of effective levee, there are on April 30, 1899, 284,032 linear feet, or 53.78 miles, built wholly or in part and paid for by the United States.

PONTCHARTRAIN LEVEE DISTRICT.

As soon as the stage of the river permitted, work was resumed at sections 15 to 40 (840 L.). Contractor Bobbitt did no work on his sections (7 and 9). He had other more important work in the Fourth district, and was granted an extension of time in which to finish those sections.

When the Belden & Seely contract for sections 51 to 78 and 81 to 88 was annulled, in February, for the reasons hereinafter stated, it was deemed advisable, if possible, to secure the improvement before high water of sections 72 to 78, inclusive, at which the existing embankment was in very inferior condition.

That work was advertised in March, put under contract the same month, and commenced at once. Good progress was made, and when the river overtopped its banks, in April, the greater part of the work had been finished.

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At sections 10 and 11 caving bank reduced the prospective life of the levee, and it was deemed inadvisable to enlarge it to the grade and cross section contemplated when the work was put under contract. A supplemental agreement was entered into with Contractor Michael Hanick, by which the full enlargement was omitted, and in lieu of it a cap having a 6-foot crown at standard grade was put on the crown only of the old levee, containing 7,961.41 cubic yards of earthwork, at 29 cents per cubic yard.

A base ditch was cut at the river toe of the slope of the old embankment extending from Station 9 of section 44 to Station 7 of section 45. This ditch measured 12 feet wide on top, 4 feet wide at bottom, 4 feet deep, and 790 feet long.

During the months of August, September, and October the entire line of levee in this district was repaired by the United States. The rain and wave wash was restored by day force; the levees were cleared of logs, weeds, and other objectionable vegetation by contract, a contract consisting of a section about 3 miles long; nearly all of the borrow pit drainage was accomplished by day force, as satisfactory bids to do this work by contract could not be secured.

Mr. Monget states that the weed cleaning, under the contract system, proved much more expensive and not as satisfactory as the old method of doing that kind of work by hired labor.

The new levee, noted in my last annual report as building by the local levee board at Margaret (862.5 L.), was completed in October, 1898. This new levee is 3,197 feet long and contains, approximately, 112,000 cubic yards of earthwork; its construction involved the abandonment of 2,798 linear feet of old levee containing 33,000 cubic yards of earthwork.

Of the total 663,500 linear feet, or 125.66 miles, of effective levee on April 30, 1899, there are 503,607 linear feet, or 95.39 miles, built wholly or in part and paid for by the United States.

In July a contract for the enlargement of 10 miles of levee, extending from 847 L., to 858 L., and embracing 459,000 cubic yards, was let to Belden & Seely, of Syracuse, N. Y., for 11 cents per cubic yard. This firm proposed to do the work with land dredges, and intended to build a sufficient number of machines to complete the contract by the required date, March 1, 1899. A dredge was moved from Syracuse, N.Y., to the work and erected at the upper end of the contract, where the levee had an average height of 16 feet, with all other conditions favorable for machine work. The dredge was operated from a car resting on a 4-foot guage track, placed on the berme of the levee, to be moved along parallel thereto. The boom was 40 feet long and equipped with a Hayward clover-leaf bucket of 2 cubic yards capacity. The work was river-side enlargement; the base of the levee measures 65 feet, and the reach of the boom was not competent to place more than 50 per cent of the required material in position. It was then decided to procure a longer boom. It was found that one 80 feet long was required to do the work, delivering all material direct. Instead of continuing operations and placing such parts of the embankment as the short boom could do, work was suspended until the long boom was procured and rigged, causing about two weeks' loss of time. The 80-foot boom consisted of one stick of yellow-pine timber 12 inches by 12 inches by 80 feet, scarcely capable, without substantial bracing, of sustaining the weight of the empty bucket. It was supported in the center by one guy only, attached to the center of the boom, and made fast to the machine. This offered little or no support, and as soon as the bucket buried itself to half its capacity and put a strain on the boom it broke. After two weeks more delay, a second stick of timber of the same dimensions was procured and rigged in the same manner.

As soon as work had been resumed the second boom parted and left the machine disabled for another long period. It was then decided to work with the original 40-foot boom, putting material in the base only, until a substantial long boom capable of doing the work could be secured. Work had continued but a few hours when the steam boiler exploded and killed the engineer, who had come with the machine from Syracuse, N. Y. This last accident, coupled with the death by yellow fever, prevailing at the time, of the foreman brought from Syracuse, seemed to completely demoralize the contractors, neither of whom was present. No one was left who seemed to know anything about running the machine, and the contractors were so discouraged that no attempt at further work was made. The remains of the machine were left at the levee until March, 1899, when they were moved away. The contractors stated that they believed their experiment a failure, that they were out a large amount of money, and were without means to do the work, and petitioned that their contract be anulled, which was granted February 16, 1899.

It is not known to what extent the machine would have proved successful under competent handling. It can not be said to have been a failure, for it is not believed to have been given a proper trial. The principles upon which it was proposed to work it are believed to be practicable, and it was only a question of making the

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several parts sufficiently strong and properly distributing the strain. Some apprehension is entertained about the weight of the dipper or bucket, which, not only on this, but on all the dredges observed, seems to be too light to sufficiently penetrate the ground in loading.

BARATARIA LEVEE DISTRICT.

During the month of June a continuous line of levees was run in this district for the purpose of developing a correct and up-to-date profile, with width of the crown of the levee, and reestablishing destroyed bench marks.

The high water of 1898 did not reach an elevation at which borrow pits could be drained and levee work proceed advantageously until October, 1898. During January, 1899, the river rose rapidly, and, destroying drainage and flooding the battures, caused a suspension of levee building. It will be observed that the working season was confined to the short time of four months, and during those months heavy and frequent rains were not only experienced, but quarantine prevailed and largely interfered with the free movement of labor and supplies. The foregoing circumstances are largely responsible for the comparatively small amount of work which has been done during the year.

Between October and December, contracts were made under the 1899 allotment for the construction of a new line at St. Rosalie (999 R.) 4,734 feet long, containing 38,119.82 cubic yards of earthwork; Treadaway (1019 R.), 1,757 feet long, containing 12,255.98 cubic yards; and Orange Farm (1025 R.), 900 feet long, containing 8,281.67 cubic yards; also for the enlargement of 16,056 linear feet of levee, embracing 55,714.02 cubic yards, at St. Ann (985 R.), Butler (1019 R.), Pelas (1032 R.), Rodey (1035 R.), Rodey Extension (1035 R.), and Booth (1039 R.).

A base ditch, measuring 4 feet wide at top, 2 feet wide at bottom, 3 feet deep, and 800 feet long, was dug at St. Rosalie (999 R.); a similar ditch, measuring 3 feet wide at top, 2 feet wide at bottom, 3 feet deep, and 900 feet long was dug at Orange Farm (1024 R.).

The new levee at St. Rosalie is only 85 feet to the rear of the existing line. In order to obtain sufficient building material, the old levee had to be cut away. Work was commenced at the lower end, and when 745 linear feet of the line had been completed the river reached a stage which overflowed the batture and prevented further work. In order to protect this country against overflow, a wing levee of reduced grade and cross section was built to connect the new and old levees.

Rapid caving of bank occurred opposite section 1 of Nairn Levee (1025 R.), and it was decided that the prospective life of the existing levee would not justify enlargement; consequently the existing contract for the enlargement of this section was annulled, and it is proposed to build a new levee there during the coming year.

Construction of the completed new levees above mentioned, together with those built by the local levee board, caused the abandonment of old levee at each locality as follows:

	Linear feet.	Cubic yards of earthwork.
West Point a la Hache	2,478	7,834
Treadaway	1,769	5,307
Orange Farm	1,054	3,700
Metcalf	498	1,130
Johnson	816	730
Popovich	400	920
Rosenbrock	1,083	2,924
Collette	443	1,240
Total	8,041	23,785

During the months of July and September the entire levee line was fully repaired. About 75 per cent of the work was done under informal contracts, each contract covering about 5 miles of levee. Mr. Klorer reports that as nearly as he can make comparison the contract system of doing the repair work is not so satisfactory, as it is considerably more costly than the old method of doing the work by hired labor.

Of the 371,709 linear feet, or 70.39 miles, of effective levee in this district, on April 30, 1899, there are 194,685 linear feet, or 36.87 miles, built wholly or in part, and paid for by the United States.

The Dilworth-Scudder Dredging Company built section 3 of Nairn Levee with a dredge, and at the present writing are building section 2 of the same levee with the same machine. The machine is somewhat smaller in size but of the same pattern

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as the one which has been worked at Barroza Levee in the Atchafalaya Levee district, and described in the early part of this report.

The boom of the dredge is 50 feet long, and as the base of the completed levee is only 40 feet, the machine is able to deliver direct, and it is not necessary to rehandle any part of the material. There is a limit to which the wet material can be pyramided, and in order to avoid loss from sloughing the dredge works over the entire line three times, adding to the material in place at each working, when that put in at the previous working has dried out. The oscillation of the river is so small at Nairn that the dredge worked at river-surface elevation at all times, and no pumping was required to keep the borrow pit flooded with water.

The dredge has made money at Nairn, though a much larger profit should have been made had the dredge been operated in a more business-like way, and the work handled in a generally more intelligent manner.

The contractors failed to clear the borrow pits of trees and stumps before the river flooded the batture, which could have been done at moderate expense; instead, much time has been lost by the dredge in digging out trees and stumps. They also failed to keep on hand a supply of parts of the machine which break easily, so that repairs could be promptly made, and as a result the dredge remained idle a good many days at a time, awaiting the arrival of a new part when there was a breakdown.

LAKE BORGNE LEVEE DISTRICT.

During the month of June a line of crown levels, similar to what is reported for the Barataria Levee district, was run.

The same unfavorable conditions as to weather and height of river during the year as is reported for the Barataria district prevailed in the Lake Borgne district, and as a result but little work has been done.

During October contracts were made under the 1899 allotment for the construction of a new line at Corinne (974 L.), 542 feet long, containing 8,966 cubic yards of earthwork, and at Caernarvon (978.5 L.), 1,850 feet long, containing 42,237.64 cubic yards of earthwork; also for the enlargement of 21,339 linear feet of levee, embracing 102,375 cubic yards of earthwork, at Corinne (973 L.) and Poydras (978 L.).

The district built a new levee at Harlem (1002 L.), 1,120 feet long and containing 14,734 cubic yards of earthwork.

At Caernarvon (978.5 L.) the old levee was used in building the new levee. Work was commenced at the upper end of the line and carried on continuously downstream. When 1,080 linear feet had been completed the river was rising very rapidly and threatened to overtop its banks; to prevent the surrounding country from being overflowed a wing levee, 225 feet long and containing 3,757 cubic yards of earthwork, was built to connect the new and old levees.

Construction of the completed new levee, built by the United States and by the local levee board, occasioned the abandonment of 600 linear feet of old levee, containing 5,400 cubic yards of earthwork, at Corinne, and 1,145 linear feet of old levee, embracing 7,557 cubic yards of earthwork, at Harlem.

During the months of August and September the levee line of the district was fully repaired, the work being done jointly by the United States and by the local levee board, the former draining the borrow pits and the latter doing all other work.

The United States work was done by informal contracts, each contract covering about 5 miles of levee.

Of the 253,336 linear feet, or 47.98 miles, of effective levee on April 30, 1899, there are 165,454 linear feet, or 31.33 miles, built wholly or in part and paid for by the United States.

Very respectfully, your obedient servant,

W. J. HARDEE, *Assistant Engineer.*

Maj. GEO. MCC. DERBY,
Corps of Engineers, U. S. A.

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APPENDIX 4-I.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 5, 1898.

No. 1.—*Abstract of proposals received in response to advertisement (circular) dated June 24, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Winter quarters.	Panola.			Duckpond.	
		Sections 3 and 4.	Section 1.	Section 2.	Sections 3 to 7.	Sections 1 to 3.	Section 4.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Donovan & Daley, Labadieville, La.	.....	14	15	15.50	.....	.....
2	M. L. Linnan, New Orleans, La	.....	11.50	12.49	.....	.....	.....
3	Batt O'Brien, Morville, La.....	39	14	18	18.90	20	17
4	L. Bland, Point Pleasant, La.....	29.45	.....	.....	.....	.....	.....
5	John G. Sessions, Leota, Miss.....	.....	.....	.....	15.90	17	.....
7	M. L. Wolf & Co., Ottumwa, Iowa .	84	11	11.50	13.25	15	15
8	Clark & Reagan, Red River Landing, La	45	16	16	18.50	16	15.50
9	Hayes Bros., Plaquemine, La.....	33	18	14	16	16	18
10	C. E. Ponder, Natchez, Miss	22.44	10.98	10.94	12.74	*a* 14.98	*a* 14.88
11	H. F. Garbish, St. Joseph, La	38	*a* 10.45	*a* 10.45	13.90	19.50	25
12	A. P. Martin, Waterproof, La.....	42	18	15	18	.....	.....
14	James R. Marlow, Natchez, Miss ..	39	.....	.....	.....	27	27
15	J. G. Boney, Duckport, La	.....	.....	.....	*a* 11	.....	.....

No.	Name and address of bidder.	Stockridge.		Waterproof.		Aquasco.
		Sections 1 to 5.	Sections 6 to 9.	Sections 1 to 4.	Sections 5 to 8.	Sections 1 to 3.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Donovan & Daley, Labadieville, La	13.50	13	12	.....	.....
2	M. L. Linnan, New Orleans, La.....	13.74	.....	12.74	.....	12.74
3	Batt O'Brien, Morville, La	13.98	11.74	12.98	17.74	13.98
5	John G. Sessions, Leota, Miss	14.75	13.90	12.90	15.90	16.45
6	Whipple & Gammill, Crowley, La.....	.....	.....	.....	.....	13.49
7	M. L. Wolf & Co., Ottumwa, Iowa.....	14	12	12½	13.75	14.50
8	Clark & Reagan, Red River Landing, La.....	*a* 13	12	12	15.50	13.90
9	Hayes Bros., Plaquemine, La	14.50	14	15	15	13.97
10	C. E. Ponder, Natchez, Miss	14.98	10.99	15.24	14.94	11.99
11	H. F. Garbish, St. Joseph, La.....	15.50	9.70	13.50	.....	.....
12	A. P. Martin, Waterproof, La	14.50	20	14.50	20	14½
13	Belden & Seely, Syracuse, N. Y	14.43	13.24	13.73	14.87	.....
14	James R. Marlow, Natchez, Miss.....	18	*a* 9.23	*a* 11.97	.....	16

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., August 31, 1898.

No. 2.—*Abstract of proposals received in response to advertisement dated August 18, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Kempe levee.
		Cents.
1	Helgason Bros., Waterproof, La.....	*a* 16.45
2	C. H. Dameron, Huntsville, Mo	27
3	John Scott & Sons, St. Louis, Mo.....	18.94
4	E. P. White, New Orleans, La	26.50
5	W. J. Bentley & Co., New Orleans, La	22.40

a Accepted. Prices bid are per cubic yard.

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UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 22, 1898.

No. 3.—*Abstract of proposals received in response to advertisement dated August 23, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Hymelia to Killona.	Pelican to Flagtown.	Lone Star.	Louisa.	Coopersville.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Hayes Bros., Plaquemine, La	a 11.75	a 12.75	a 18	16	18
2	Donovan & Daley, Labadieville, La	12.70	16.90	.....	a 13.90	17
3	J. A. Andrews & Son, New Orleans, La	15.50	16	23	14	a 14.75

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 22, 1898.

No. 4.—*Abstract of proposals received in response to advertisement dated August 23, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Hermitage.	Beaulieu to Antonio.	Missouri.	Australia.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	M. L. Linnan, Point Coupee, La	.....	a 10.97	.....	a 10.97
2	Thomas Whelan, Sunshine, La	.....	14	.....	.....
3	Israel R. Bobbitt, Arbroth, La	.....	13.50	a 14.50	.....
4	Batt O'Brien, Morville, La	33	14	15	.....
5	George Byrne, Port Allen, La	.....	12.40	16.50	16.50
6	Donovan & Daley, Labadieville, La	35	13.70	14.90	17.90
7	Hearin & O'Connor, Point Coupee, La	.....	12.95	.....	.....
8	J. A. Andrews & Son, New Orleans, La	.....	19	19.50	16.50

a Accepted. Prices bid are per cubic yard

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 23, 1898.

No. 5.—*Abstract of proposals received in response to advertisement dated August 29, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Winter quarters.	Esperanza.		Ashley.			
			Sections 1 to 4.	Sections 16 to 19.	Sections 1 to 3.	Sections 4 to 6.	Sections 7 to 10.	Sections 11 to 13.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	C. E. Ponder, St. Joseph, La	29.50	.....	.....	.....	.....	.....	.....
2	John Scott & Sons, St. Louis, Mo	.....	.....	.....	a 11.36	a 11.36	a 11.36	a 11.36
3	H. J. Loonam, Morville, La	.....	.....	.....	12.70	.....	.....	.....
4	Donovan & Daley, Baton Rouge, La	.....	.....	.....	13.70	13.70	13.70	13.70
5	Batt O'Brien, Morville, La	39.74	a 19.90	49.99	13.73	12	13.98	11.98
6	Bush Bros., Artonish, Miss	.....	23½	44½	12.74	12.74	13.90	13.90
7	James R. Marlow, Waterproof, La	.....	.....	.....	11.94	.....	.....	.....

a Accepted. Prices bid are per cubic yard.

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UNITED STATES ENGINEER OFFICE,
New Orleans, La., October 10, 1898.

No. 6.—*Abstract of proposals received in response to advertisement dated September 10, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Corrinne, sections 1 to 5.	Poydras, sections 1 and 2.	Caernarvon, sections 1 to 3.	Orange Grove, sections 1 and 2.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	S. D. Moody, New Orleans, La	19	16.90	16.90	21
2	George Jurgens, New Orleans, La	a 14.74	.....	16.94	15.85
3	Thomas Egan, jr., New Orleans, La	17.50	16.75	a 16	15
4	J. F. Brennan, New Orleans, La	.....	19.74	.....	.....
5	Narcisse Nereaux, Poydras, La	.....	21.25	22.75	.....
6	John F. Meyer, English Turn, La	.....	a 14.90	.....	15.90

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., October 19, 1898.

No. 7.—*Abstract of proposals received in response to advertisement dated September 21, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	St. Ann.	Concession.	Concord to Augusta.	St. Rosalie.	Treadaway.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
2	Robt. McNamara, New Orleans, La	.....	.....	.....	.....	13
3	George Jurgens, New Orleans, La	.....	.....	.....	15.90	15.92
4	Thomas Egan, jr., New Orleans, La	16	16	15.75	14.75	.....
5	S. D. Moody, New Orleans, La	.....	.....	15	15	.....
6	J. D. Willis, St. James, La	14	.....	.....	.....	.....
7	C. R. Sarpy, Jesuits Bend, La	14	15	.....	.....	.....
8	Michael Cullen, New Orleans, La	12.60	12.90	.....	.....	11.47
9	Thomas B. Cleary, New Orleans, La	16	.....	.....	12.48	.....

No.	Name and address of bidder.	Butler.	Orange Farm.	Pelas.	Rodey.	Booth.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Geo. E. Booth, Triumph, La	.....	.....	.....	.....	15.00
2	Robt. McNamara, New Orleans, La	13.00	a 14.75	a 13½	a 15.50	a 13.75
3	George Jurgens, New Orleans, La	14.25	.....	14.75	.....	.....
8	Michael Cullen, New Orleans, La	11.47	.....	.....	.....	.....

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., November 10, 1898.

No. 8.—*Abstract of proposals received in response to advertisement dated October 29, 1898, opened this day by Maj. J. H. Willard, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	St. Ann.	St. Rosalie.	Treadaway.	Butler.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	Wade Bros. Construction Co., St. Louis	.....	a 13.50	16	.....
2	George Jurgens, New Orleans, La	.....	14.22	.....	.....
3	W. F. Barbour & Son, New Orleans	.....	13.70	.....	.....
4	Michael Cullen, New Orleans, La	a 13.25	.....	a 11.88	11.88

a Accepted. Prices bid are per cubic yard.

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UNITED STATES ENGINEER OFFICE,
New Orleans, La., December 23, 1898.

No. 9.—*Abstract of proposals received in response to advertisement dated December 13, 1898, opened this day by Capt. Henry Jervey, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Robertson.		Rodey Extension.
		Section 1.	Section 2.	
		Cents.	*Cents.*	*Cents.*
1	W. O. Flynn, New Orleans, La	31.75	31.75	.....
2	Robt. McNamara, New Orleans, La	.....	.....	a 17
3	W. F. Barbour & Son, New Orleans, La	a 22	a 22	.....
4	J. L. Buras, Buras, La	.....	.....	19.75

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February 11, 1899.

No. 10.—*Abstract of proposals received in response to advertisement (circular) dated February 1, 1899, opened this day by Capt. Henry Jervey, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

No.	Name and address of bidder.	Palmyra Island.
		Cents.
1	Clark & Reagan, Goldman, La	16.23
2	T. A. Helgason, Goldman, La	a 10.90
3	H. J. Loonam, Goldman, La	11.40

a Accepted. Prices bid are per cubic yard.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February 20, 1899.

No. 11.—*Abstracts of proposals received in response to advertisement (circular) dated February 7, 1899, opened this day by Capt. Henry Jervey, Corps of Engineers, for levee work in the Fourth district, improving Mississippi River.*

PONTCHARTRAIN LEVEE DISTRICT.

No.	Name and address of bidder.	Sections.						
		72	73	74	75	76	77	78
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	W. O. Flynn, New Orleans, La	23.7	23.7	23.7	23.7	23.7	23.7	23.7
2	Hearin & O'Connor, Baton Rouge, La.	17.50	.....	.....	.....	.....	.....	.....
3	Clark & Reagan, Red River Landing, La.	a 13.23	a 13.23	a 15	12.45	12.45	a 12.45	12.45

a Accepted. Prices bid are per cubic yard.

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APPENDIX 4 J.

List of contracts in force, Fourth district, improving Mississippi River, with names of contractors, dates of approval of contracts, dates of beginning work, expiration of time for completion, and extensions granted.

No.	Name of levee.	Below Cairo.		Contractor.
		Miles.	Bank.	
1	Kempe	657	R.	Helgason Bros.
2	Esperanza, sections 2 to 4, inclusive	711	R.	Batt O'Brien.
3	Ashley, sections 1 to 11, inclusive	724	R.	John Scott & Sons.
4	Nina, sections 6 and 8	806	R.	F. M. McLaughlin.
5	Beaulieu to Antonio, sections 1, 2, and 5	836	R.	M. L. Linnan.
6	Missouri, sections 2 to 4, inclusive	840	R.	I. R. Bobbitt.
7	Australia, sections 1 and 2	846	R.	M. L. Linnan.
8	Hymelia to Killona, sections 1 to 5, inclusive	930	R.	Hayes Bros.
	Pelican to Flagtown, section 5	936	R.	
	Lone Star	942	R.	
9	Louisa, section 2	943	R.	Donovan & Daly.
10	Coopersville	944	R.	James A. Andrews & Son.
11	St. Ann	985	R.	Michael Cullen.
12	St. Rosalie, sections 1 and 2	999	R.	Wade Bros. Construction Co.
13	Ballay to Orange Farm, section 4	1,023	R.	Victor Adema.
14	Pelas	1,032	R.	Robert McNamara.
	Rodey	1,035	R.	
	Booth	1,039	R.	
15	Sections 7 and 9, Pontchartrain district	836	L.	Israel R. Bobbitt.
16	Sections 48 to 50 and 97 to 103, inclusive, Pontchartrain district.	861	L.	Michael Hanick.
17	Corinne, sections 1 and 2	972.5	L.	George Jurgens.
18	Poydras, section 2	978	L.	John F. Meyer.
19	Caernarvon, sections 2 and 3	978.5	L.	Thomas Egan, jr.
20	1 steel towboat	.....	.....	The Iowa Iron Works, Limited.
21	2 decked barges	.....	.....	Cincinnati Marine Rwy. Co.
22	Steel hull, etc., for dredge The Ram	.....	.....	Springfield Boiler and Manufacturing Co.

No.	Name of levee.	Date of approval.	Date of beginning work.	Date of expiration of contract.	Extension of time granted.
1	Kempe	Oct. 21, 1898	Sept. 6, 1898	Dec. 31, 1898	Apr. 1, 1899
2	Esperanza, sections 2 to 4, inclusive	Nov. 14, 1898	Oct. 24, 1898	Mar. 1, 1899	
3	Ashley, sections 1 to 11, inclusive	Nov. 5, 1898	Nov. 21, 1898	.....do	May 1, 1899
4	Nina, sections 6 and 8	Feb. 11, 1898	Jan. 15, 1898	Jan. 1, 1899	June 1, 1899
5	Beaulieu to Antonio, sections 1, 2, and 5	Dec. 29, 1898	Oct. 10, 1898	Mar. 1, 1899	
6	Missouri, sections 2 to 4, inclusive	Oct. 24, 1898	.....do	.....do	May 1, 1899
7	Australia, sections 1 and 2	Dec. 29, 1898	.....do	.....do	
8	Hymelia to Killona, sections 1 to 5, inclusive	Nov. 10, 1898	.....do	.....do	
	Pelican to Flagtown, section 5				
	Lone Star				
9	Louisa, section 2	Nov. 5, 1898	.....do	.....do	
10	Coopersville	Oct. 24, 1898	.....do	.....do	
11	St. Ann	Jan. 6, 1898	Nov. 29, 1898	.....do	
12	St. Rosalie, sections 1 and 2	Apr. 26, 1899	Dec. 5, 1898	.....do	
13	Ballay to Orange Farm, section 4	Nov. 17, 1897	Jan. 15, 1898	Feb. 1, 1898	
14	Pelas	Nov. 22, 1898	Nov. 25, 1898	Mar. 1, 1899	
	Rodey				
	Booth				
15	Sections 7 and 9, Ponchartrain district	Sept. 16, 1897	Sept. 1, 1897	Mar. 1, 1898	
16	Sections 48 to 50 and 97 to 103, inclusive, Ponchartrain district	Jan. 31, 1898	Jan. 15, 1898	Jan. 1, 1899	May 1, 1899
17	Corinne, sections 1 and 2	Nov. 10, 1898	Oct. 25, 1898	Mar. 1, 1899	
18	Poydras, section 2	Nov. 8, 1898	Oct. 31, 1898	.....do	
19	Caernarvon, sections 2 and 3	Nov. 5, 1898	.....do	.....do	
20	1 steel towboat	Mar. 29, 1898	Mar. 20, 1898	Aug. 4, 1898	Mar. 1, 1899
21	2 decked barges	Jan. 6, 1899	Feb. 27, 1899	Mar. 1, 1899	June 20, 1899
22	Steel hull, etc., for dredge The Ram	Mar. 25, 1899		July 30, 1899	

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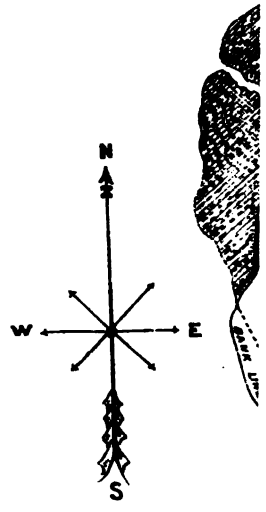

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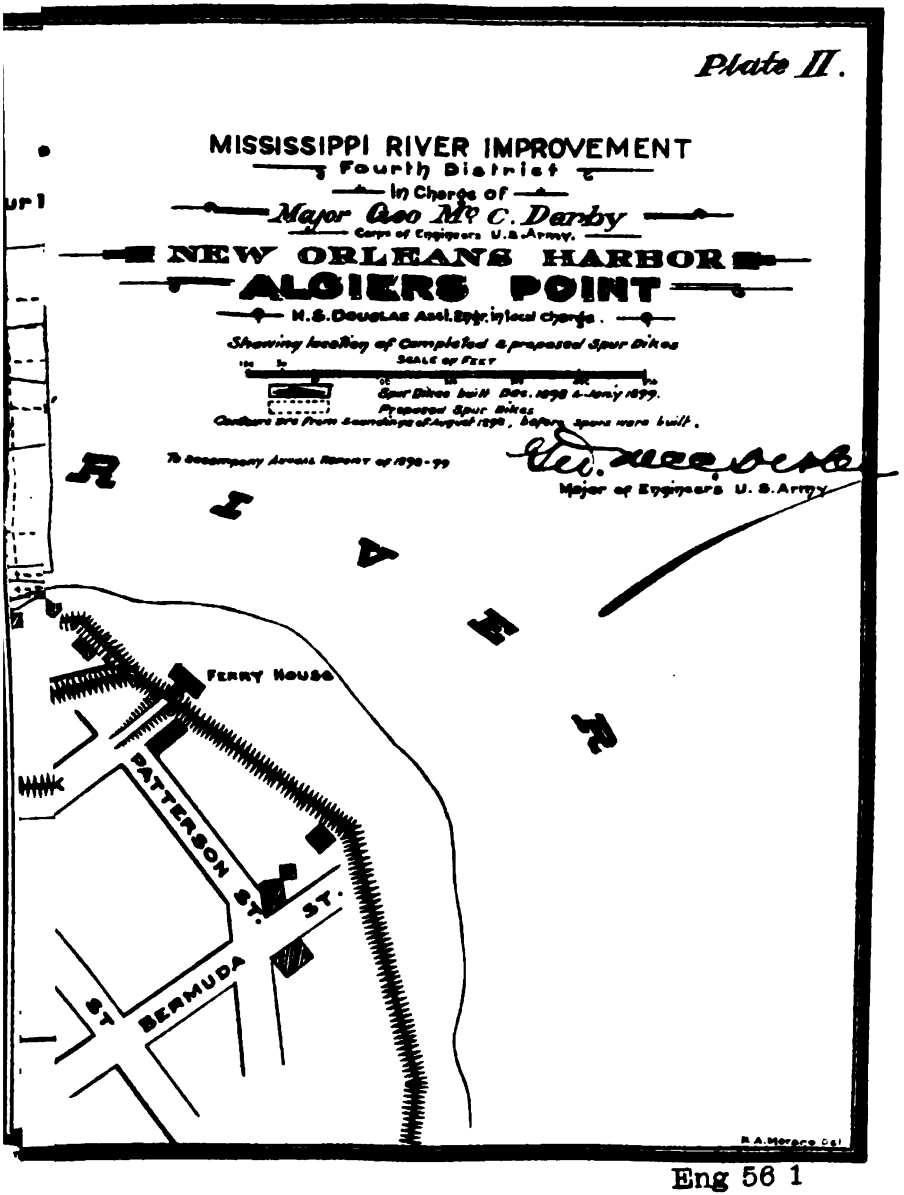
Plate II.
MISSISSIPPI RIVER IMPROVEMENT
Fourth District
In Charge of
Major Geo Mc C. Derby
Corps of Engineers U.S.Army.
NEW ORLEANS HARBOR
ALGIERS POINT
H.S. DOUGLAS Asst. Engr. in local charge.
Showing locality of Completed & proposed Spur Dikes
SCALE OF FEET
Spur Dikes built Dec. 1898 & Jany 1899.
Proposed Spur Dikes
Contours are from Soundings of August 1898, before spurs were built.
To accompany Annual Report of 1898-99
Major of Engineers U. S. Army
FERRY HOUSE
PATTERSON ST.
BERMUDA ST.
ST
R. A. Morgan Del

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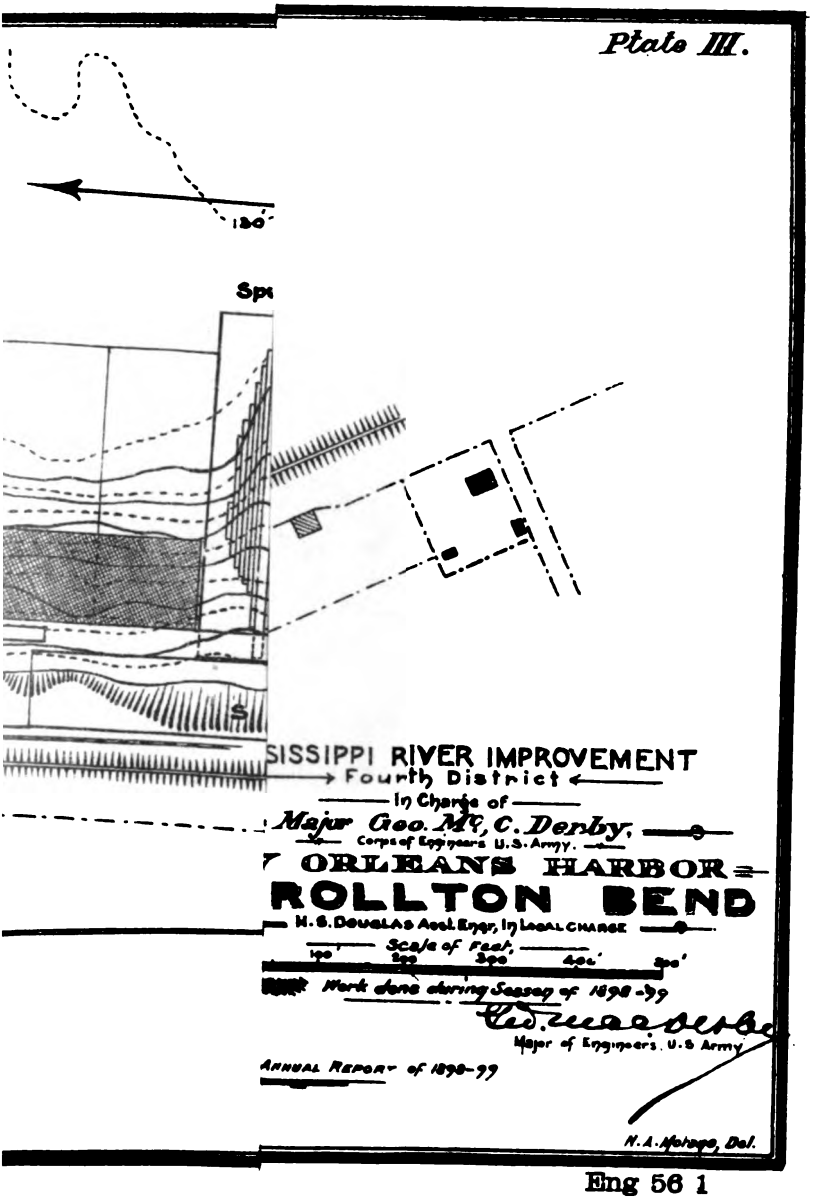

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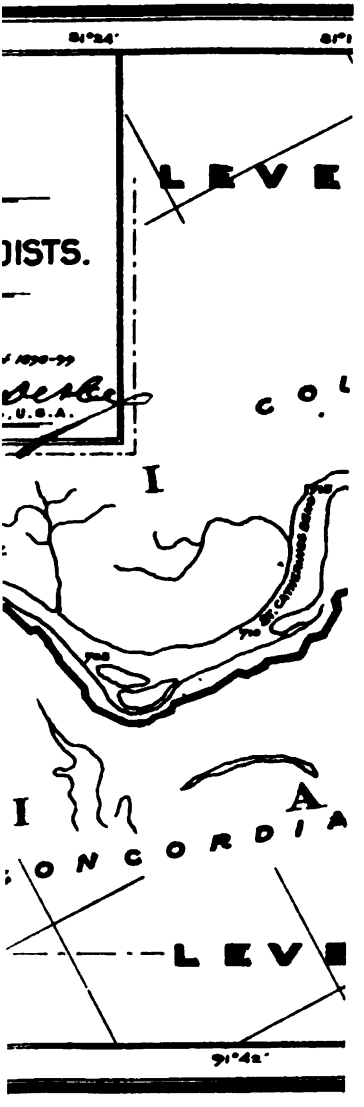

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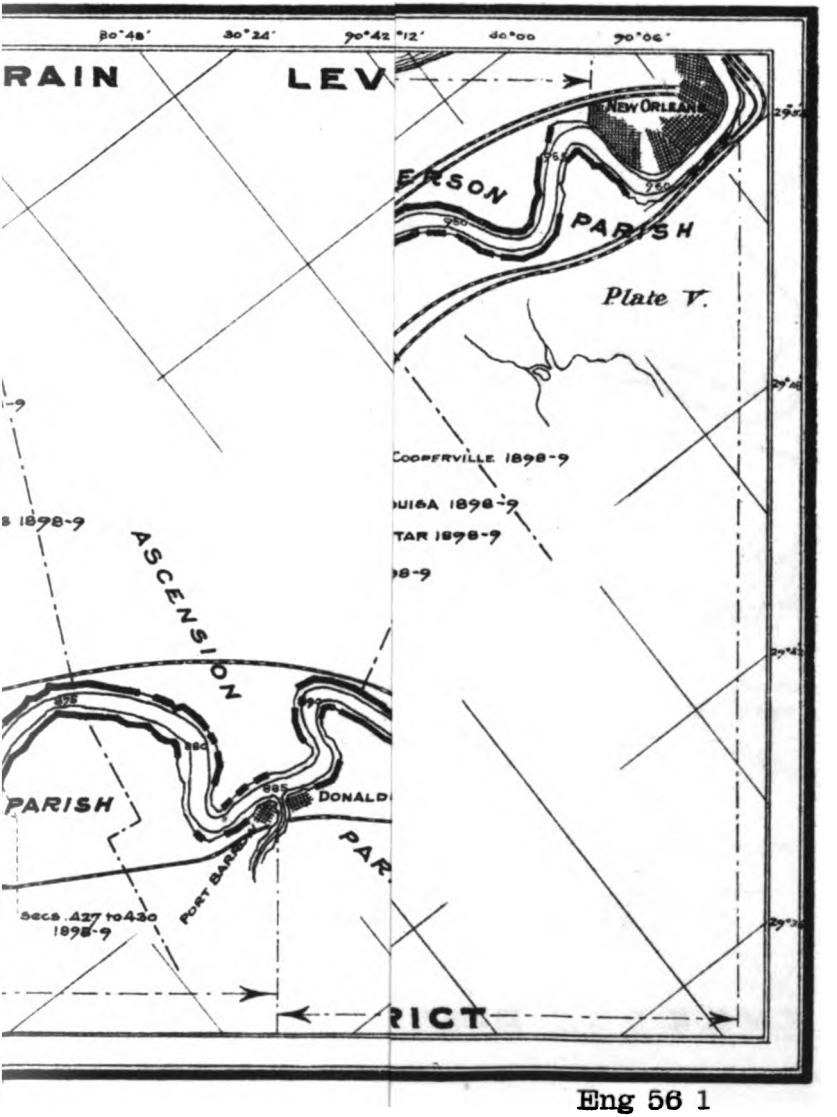

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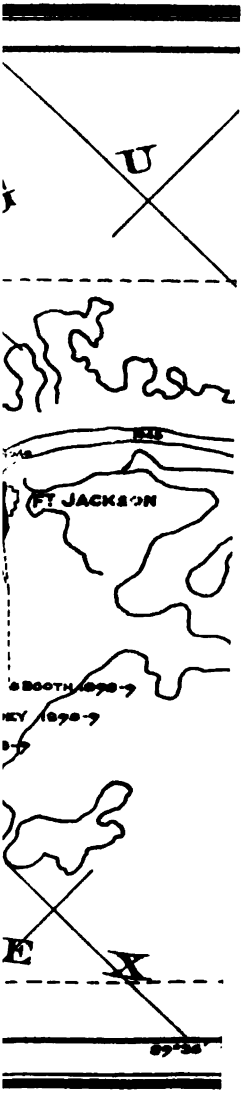

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